Data Communication & Networks

Chapter 3: Data Link Layer

Data Link Layer

Data Link Layer Design Issues

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

Data link Layer

- Physical layer delivers bits of information to and from data link layer. The functions of Data Link Layer are:
  1. Providing a well-defined service interface to the network layer.
  2. Dealing with transmission errors.
  3. Regulating the flow of data so that slow receivers are not swamped by fast senders.

- Data Link layer
  - Takes the packets from Physical layer, and
  - Encapsulates them into **frames**

Services Provided to Network Layer

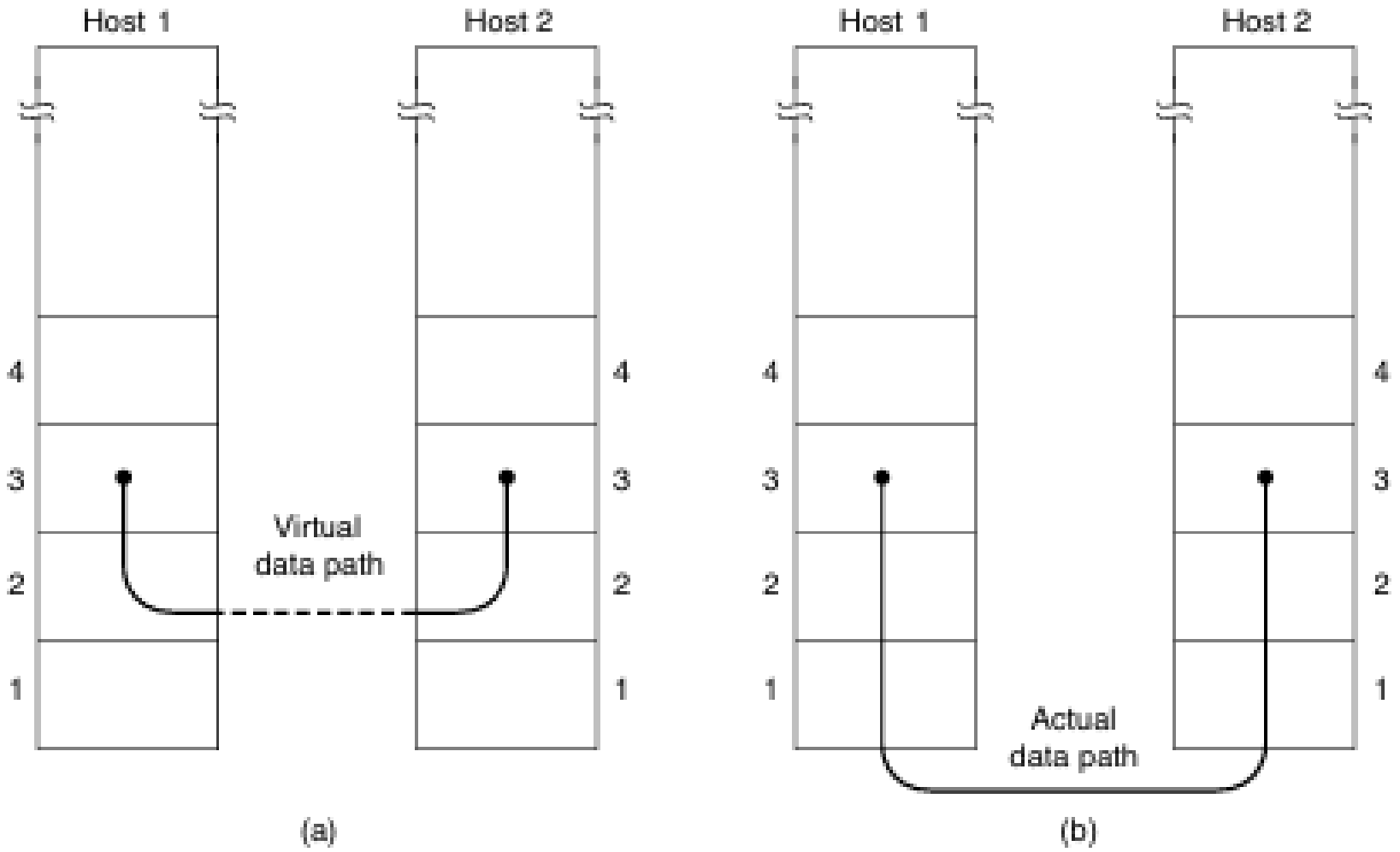
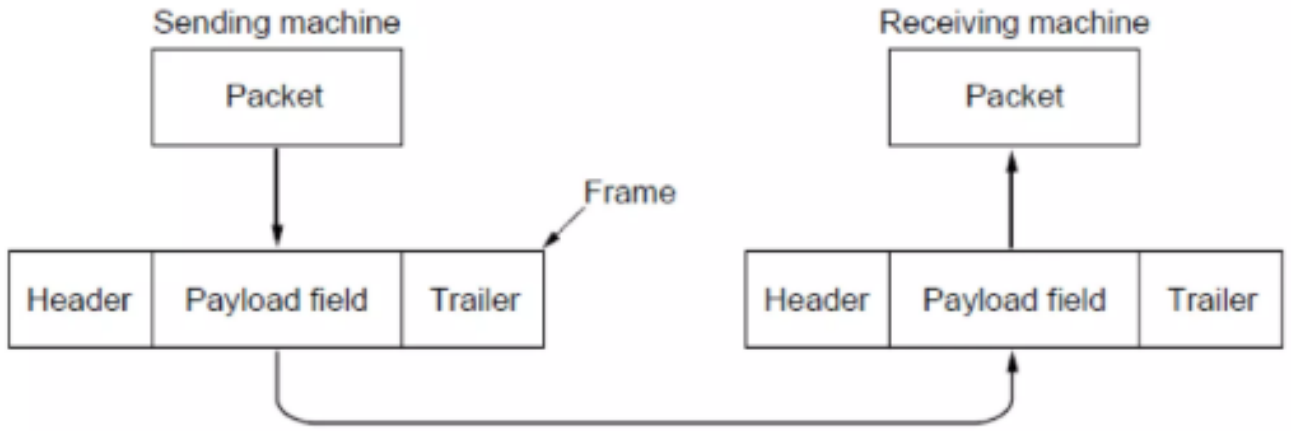


Figure 3-2. (a) Virtual communication. (b) Actual communication.

Packets and Frames

Packets and Frames



Relationship between packets and frames.

- Header: Source address/ Destination address
- Trailer: Error detecting/correcting codes

Services Offered

Possible Services Offered

1. Unacknowledged connectionless service.
2. Acknowledged connectionless service.
3. Acknowledged connection-oriented service.

Services Offered

Unacknowledged Connectionless Service

- It consists of having the source machine send independent frames to the destination machine without having the destination machine acknowledge them.
- Example: Ethernet, Voice over IP, etc. in all the communication channel were real time operation is more important that quality of transmission.

Services Offered

Acknowledged Connectionless Service

- Each frame send by the Data Link layer is acknowledged and the sender knows if a specific frame has been received or lost.
- Typically the protocol uses a specific time period that if has passed without getting acknowledgment it will re-send the frame.
- This service is useful for commutation when an unreliable channel is being utilized (e.g., 802.11 WiFi).

- Network layer does not know frame size of the packets and other restriction of the data link layer. Hence it becomes necessary for data link layer to have some mechanism to optimize the transmission.

Services Offered

Acknowledged Connection Oriented Service

- Source and Destination establish a connection first.
- Each frame sent is numbered
  - Data link layer guarantees that each frame sent is indeed received.
  - It guarantees that each frame is received only once and that all frames are received in the correct order.
- Examples:
  - Satellite channel communication,
  - Long-distance telephone communication, etc.

Framing

Framing

- Transmission of the data link layer starts with breaking up the bit stream
  - into discrete frames
  - Computation of a checksum for each frame, and
  - Include the checksum into the frame before it is transmitted.
- Receiver computes its checksum error for a receiving frame and if it is different from the checksum that is being transmitted will have to deal with the error.

- Framing is more difficult than one could think!

Framing

Framing Methods

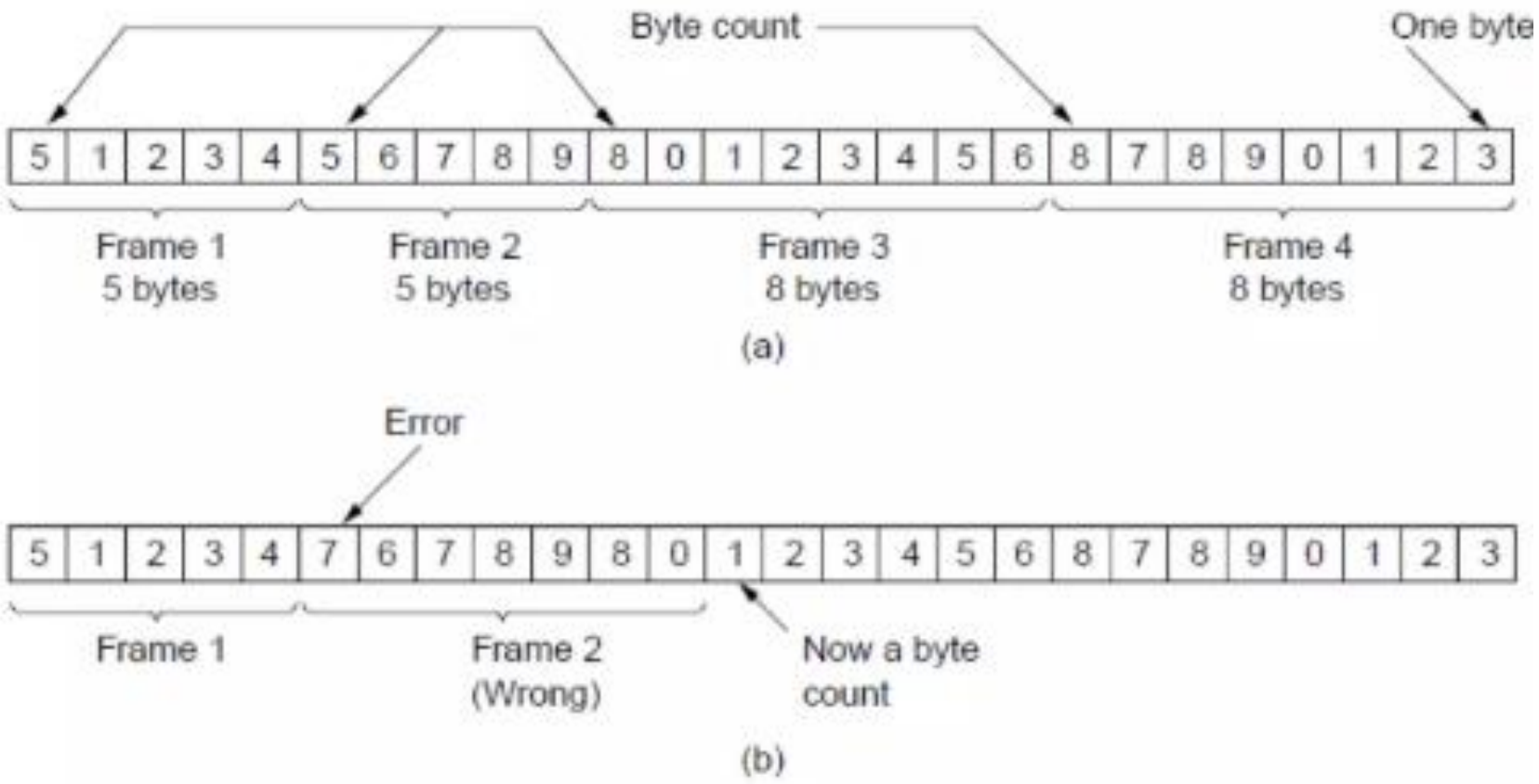
1. Byte count.
2. Flag bytes with byte stuffing.
3. Flag bits with bit stuffing.
4. Physical layer coding violations.

Framing Method 1

Byte Count Framing Method

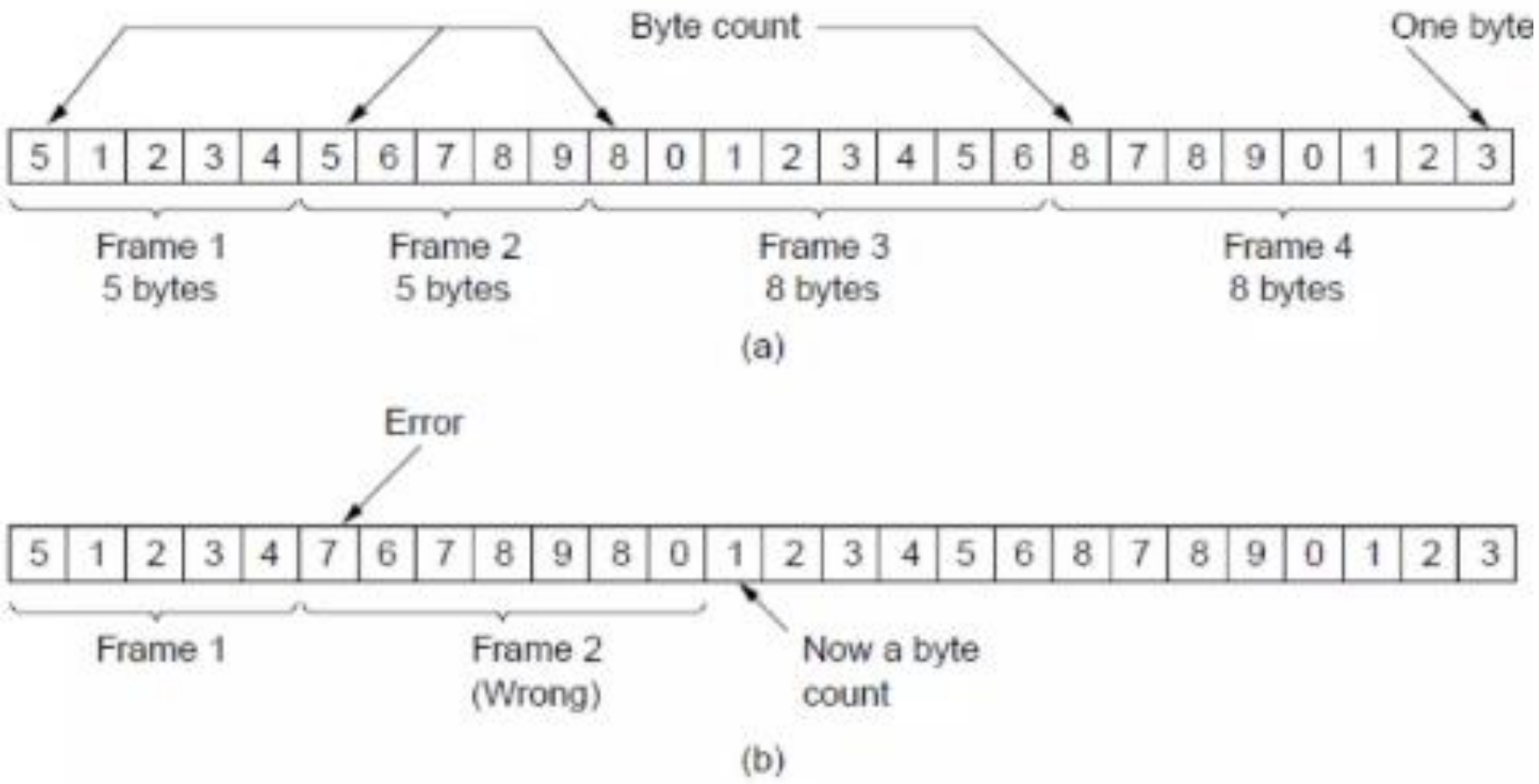
- It uses a field in the header to specify the number of bytes in the frame.
- Once the header information is being received it will be used to determine end of the frame.
- See figure in the next slide:
- Trouble with this algorithm is that when the count is incorrectly received the destination will get out of synch with transmission.
  - Destination may be able to detect that the frame is in error but it does not have a means (in this algorithm) how to correct it.

Framing Method 1



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

Framing Method 1



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

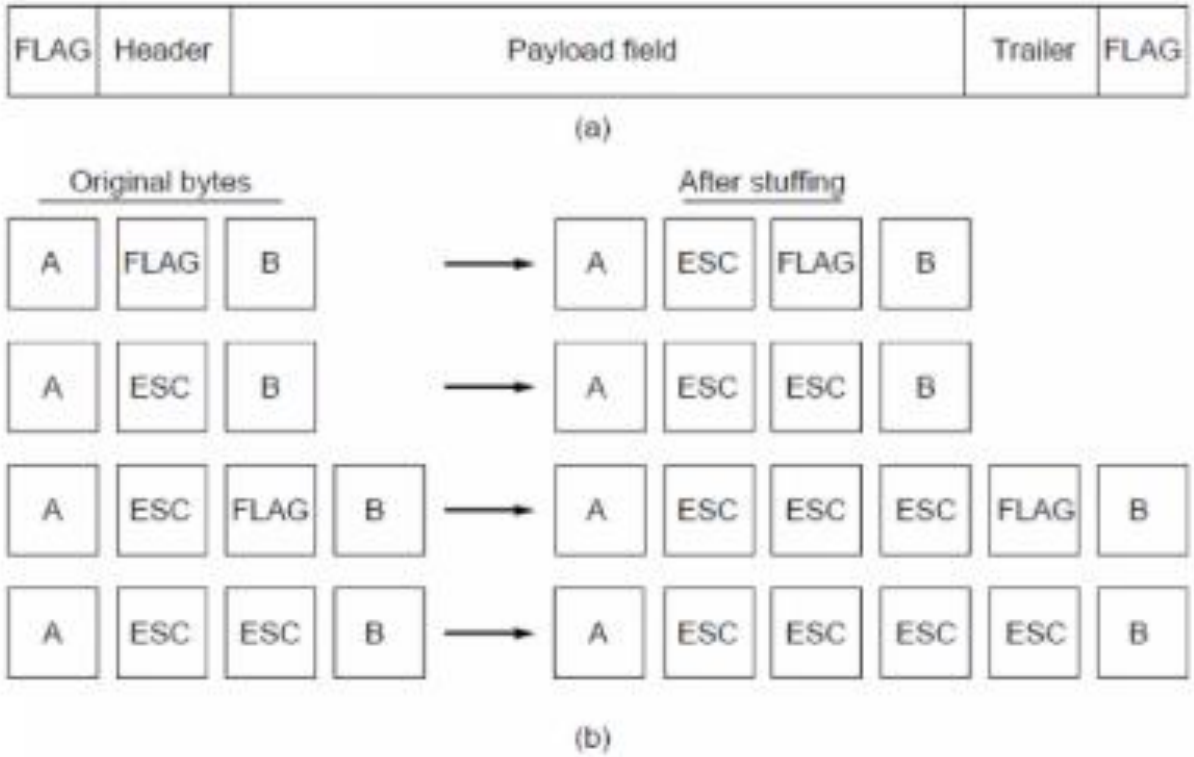
Framing Method 2

Flag Bytes with Byte Staffing Framing Method

- This methods gets around the boundary detection of the frame by having each appended by the frame start and frame end special bytes.
- If they are the same (beginning and ending byte in the frame) they are called **flag byte**.
- In the next slide figure this byte is shown as FLAG.
- If the actual data contains a byte that is identical to the FLAG byte (e.g., picture, data stream, etc.) the convention that can be used is to have escape character inserted just before the "FLAG" character.

Framing Method 2

Framing (2)



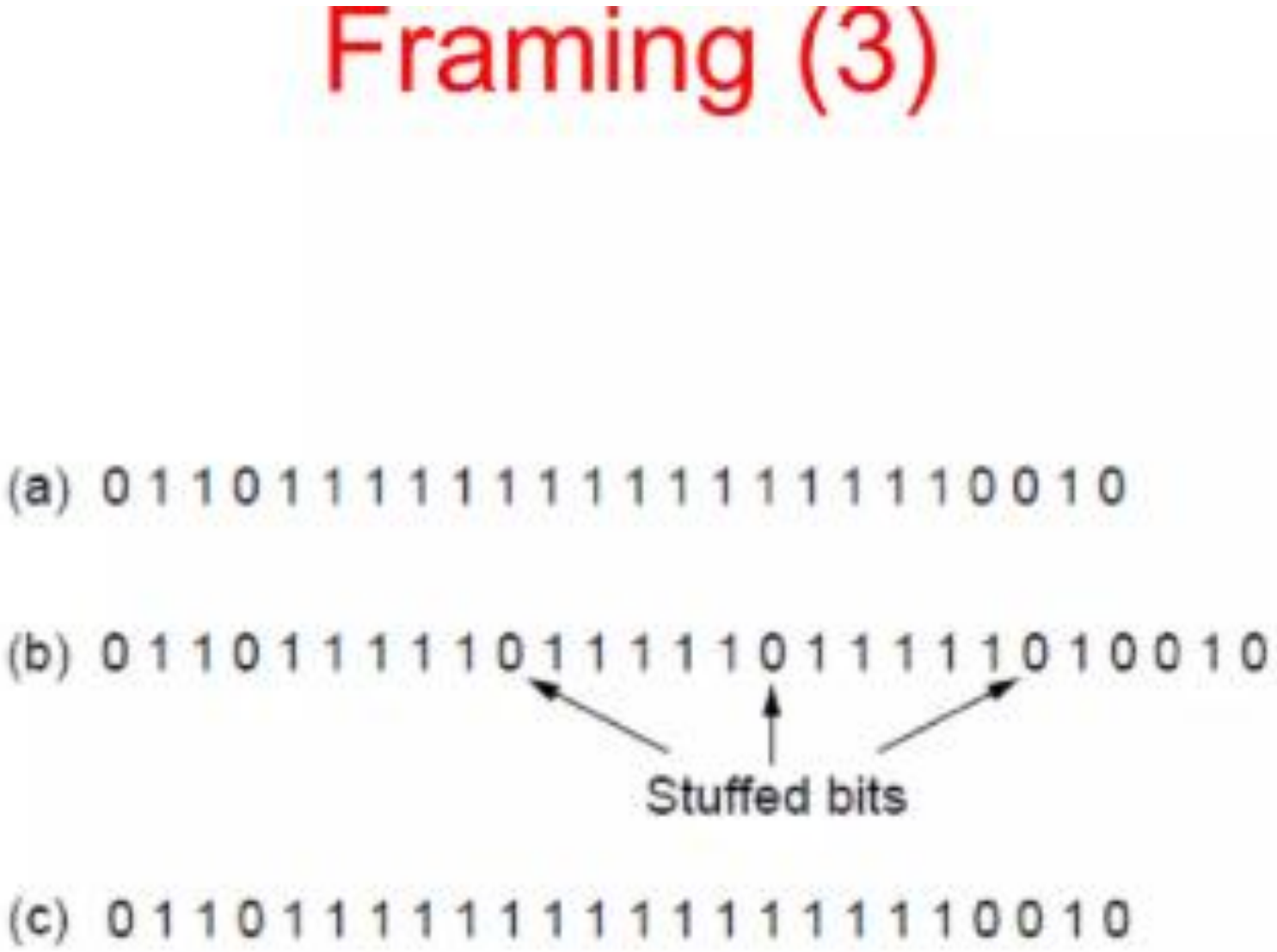
a) A frame delimited by flag bytes.

b) Four examples of byte sequences before and after byte stuffing.

Bit Stuffing

- This methods achieves the same thing as Byte Stuffing method by using Bits (1) instead of Bytes (8 Bits).
- It was developed for High-level Data Link Control (HDLC) protocol.
- Each frames begins and ends with a special bit patter:
  - 01111110 or 0x7E <- Flag Byte
  - Whenever the sender's data link layer encounters five consecutive 1s in the data it automatically stuffs a 0 bit into the outgoing bit stream.
  - USB uses bit stuffing.

Framing Method 3: Bit Stuffing



Data Link Layer

Data Link Layer Design Issues

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

Error Control: Error Detection and Error Correction

- Error Detection
- Error correction

Error Detection: Error Detecting Codes

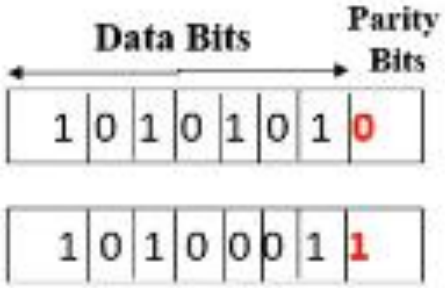
Linear, systematic block codes

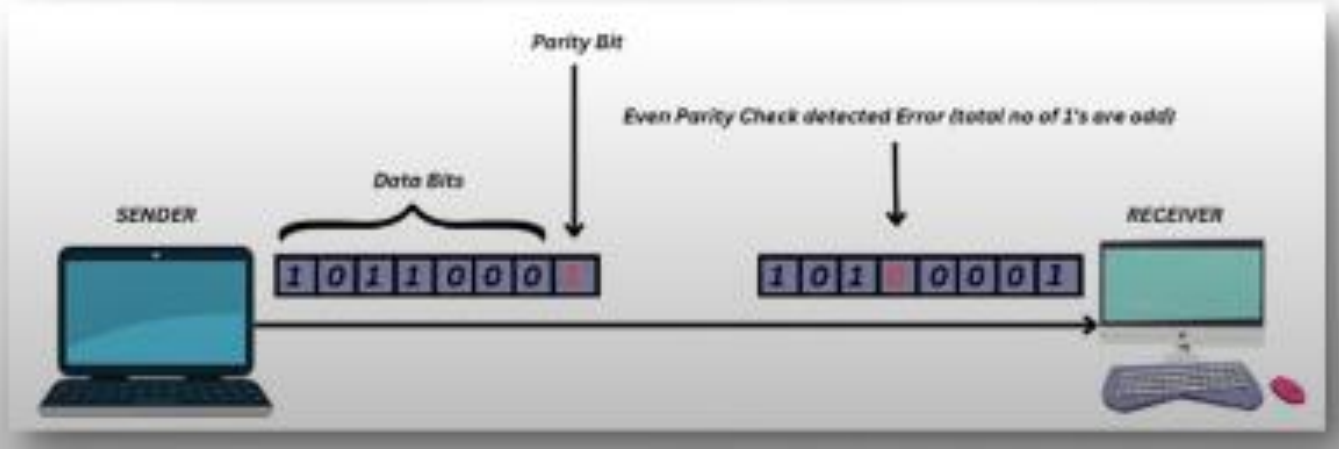
1. Parity.
2. Checksums.
3. Cyclic Redundancy Checks (CRCs).

Error Detection: Method 1 (Parity Bits)

- The parity bit is extra bit added to the message from sender side, to help in error detection at the receiver side.
- Also called as Data-word bits or Codeword.

1. **Even Parity:** If number of 1s is even in data bits, parity bit value is **0**.
2. **Odd Parity:** If number of 1s is odd in data bits, parity bit value is **1**.





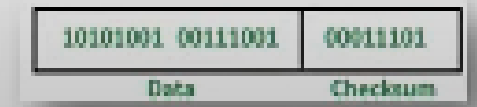
Error Detection: Method 2 (Checksum)

- It detects all errors involving an odd number of bits as well even number of bits.
- In checksum, at each word is transmitted it is added to previously send words & sum is retained at transmitter.

➢ **Example:**

Subunit 1 :	1 0 1 0 1 0 0 1	1 0 1 0 1 0 0 1	**Subunit 1**
Subunit 2 :	0 0 1 1 1 0 0 1	0 0 1 1 1 0 0 1	**Subunit 2**
Sum :	1 1 1 0 0 0 1 0	1 1 1 0 0 0 1 0	**Sum**
Checksum :	0 0 0 1 1 1 0 1	0 0 0 1 1 1 0 1	**Checksum**

(Compliment of 1's)

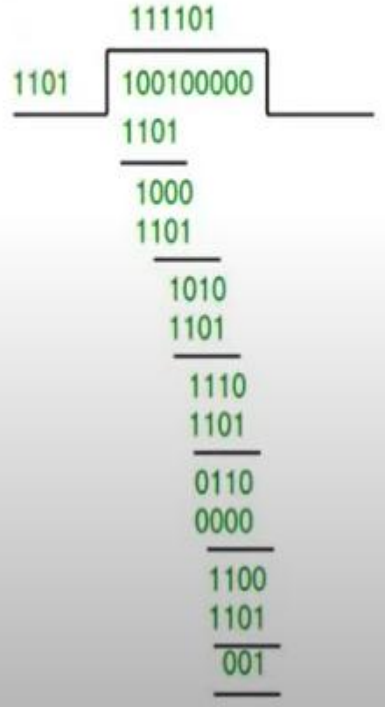


Error Detection: Method 3 (Cyclic Redundancy Check)

- CRC is a method of detecting accidental changes/errors in the communication channel.
- CRC uses Generator Polynomial which is available on both sender and receiver side.

Example:

Sender



Data Words sent : 1 0 0 1 0 0
Key: 1 1 0 1

Reminder : 0 0 1

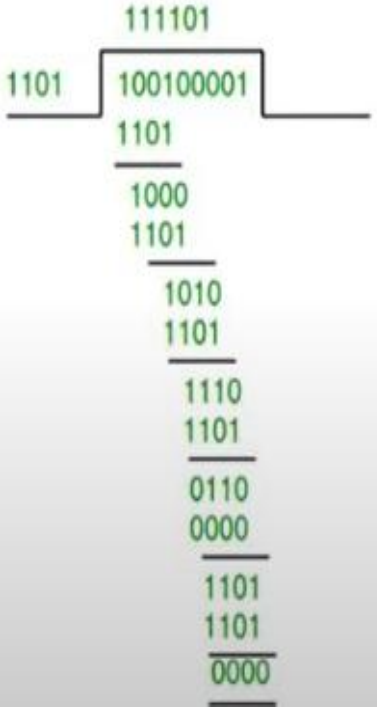
Data Sent : 1 0 0 1 0 0 0 0 1

Receiver

Data Words sent : 1 0 0 1 0 0
Key: 1 1 0 1

Reminder : 0 0 1

Data Sent : 1 0 0 1 0 0 0 0 1



Error Detection & Error Correction: Hamming Code

- Hamming code Done in Lecture. See Lecture Notes