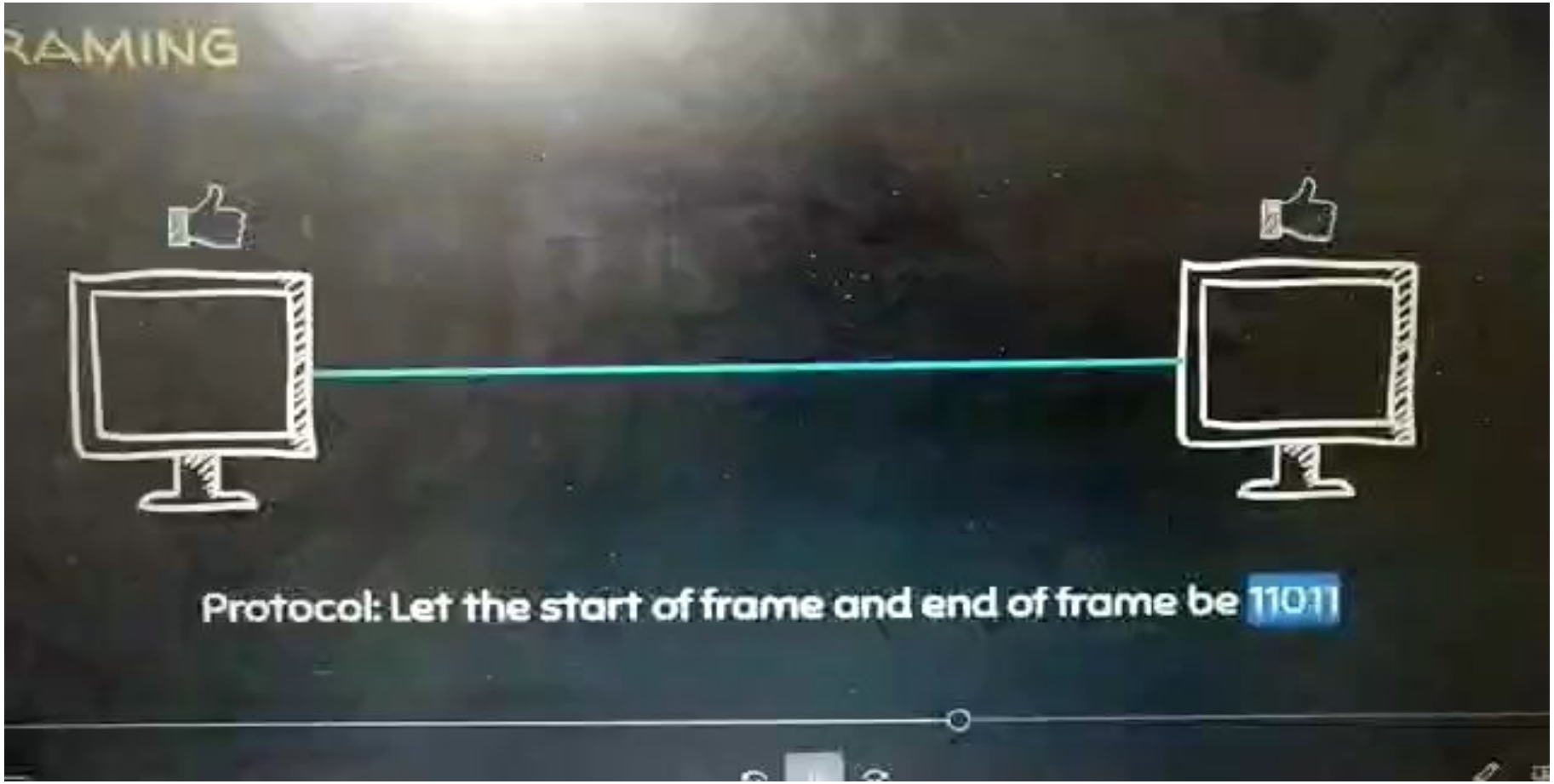
Data Link layer

Framing

- ★ When node A wishes to transmit a frame to node B, it tells its adaptor to transmit a frame from the node's memory.
- ★ This results in a sequence of bits being sent over the link.
- ★ The adaptor on node B then collects together the sequence of bits arriving on the link and deposits the corresponding frame in B's memory.
- ★ Challenge: What set of bits constitute a frame?

Bits flow between adaptors, frames between hosts


RAMING
Protocol: Let the start of frame and end of frame be 11011

Types of Framing

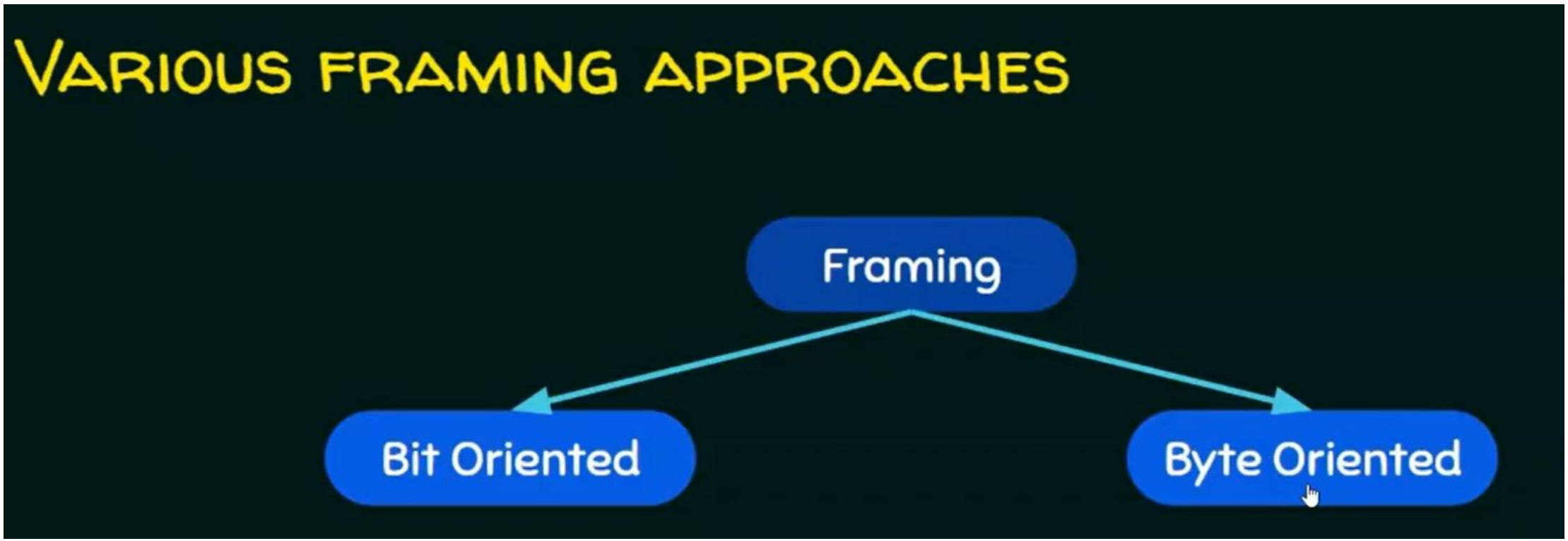
Types of framing

1. Fixed-size framing.

- ★ Here the size of the frame is fixed and so the frame length acts as delimiter of the frame.
- ★ Consequently, it does not require additional boundary bits to identify the start and end of the frame.

2. Variable-size framing.

- ★ Here, the size of each frame to be transmitted may be different.
- ★ So additional mechanisms are kept to mark the end of one frame and the beginning of the next frame.


VARIOUS FRAMING APPROACHES
Framing
Bit Oriented
Byte Oriented

Bit oriented approach

- ★ It simply views the frame as a collection of bits.
- ★ In bit-oriented framing, data is transmitted as a sequence of bits that can be interpreted in the upper layers both as text as well as multimedia data.

Bit oriented protocol

- ★ HDLC <-> High-Level Data Link Control

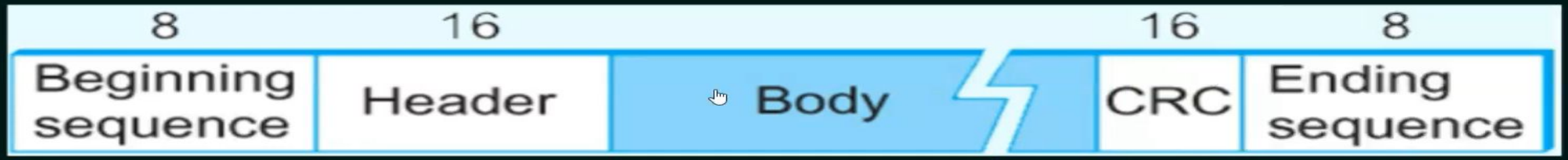
Byte oriented approach

- ★ One of the oldest approaches to framing.
- ★ Here each frame is viewed as a collection of bytes (characters) rather than bits.
- ★ a.k.a Character Oriented Approach.

Byte oriented protocols

- ★ BISYNC <-> Binary Synchronous Communication Protocol.
- ★ DDCMP <-> Digital Data Communication Message Protocol.
- ★ PPP <-> Point-to-Point Protocol

HDLC – Frame format



Beginning and Ending Sequences: 01111110

This sequence is also transmitted during any times that the link is idle so that the sender and receiver can keep their clocks synchronized.

Header: Address and Control Field.

Body: Payload (Variable size)

CRC: Cyclic Redundancy check – Error Detection

Types of HDLC Frames

The type of frame is determined by the control field.

I-Frame: Information Frame.

S-Frame: Supervisory Frame.

U-Frame: Un-numbered Frame.

I-Frame	1st bit is 0
S-Frame	1st two bits is 10
U-Frame	1st two bits is 11

PPP

- ★ PPP is a data link layer protocol.
- ★ PPP is a WAN protocol and which is commonly run over Internet links.
- ★ It is widely used in broadband communications having heavy loads and high speeds.
- ★ It is used to transmit multiprotocol data between two directly connected (point-to-point) computers.

PPP Frame format

★ Flag – 1 byte that marks the beginning and the end of the frame. The bit pattern of the flag is 01111110.

★ Address – 1 byte which is set to 11111111 in case of broadcast.

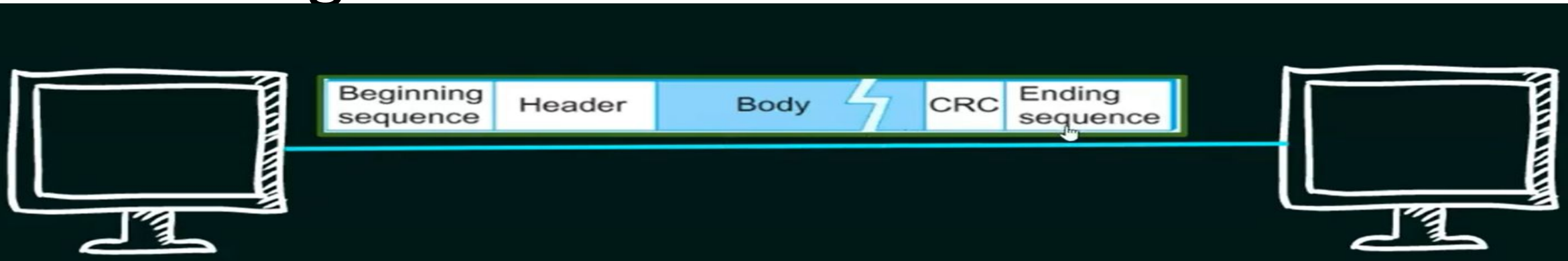
★ Control – 1 byte set to a constant value of 11000000.

★ Protocol – 1 or 2 bytes that define the type of data contained in the payload field.

★ Payload – This carries the data from the network layer. The maximum length of the payload field is 1500 bytes. However, this may be negotiated between the endpoints of communication.

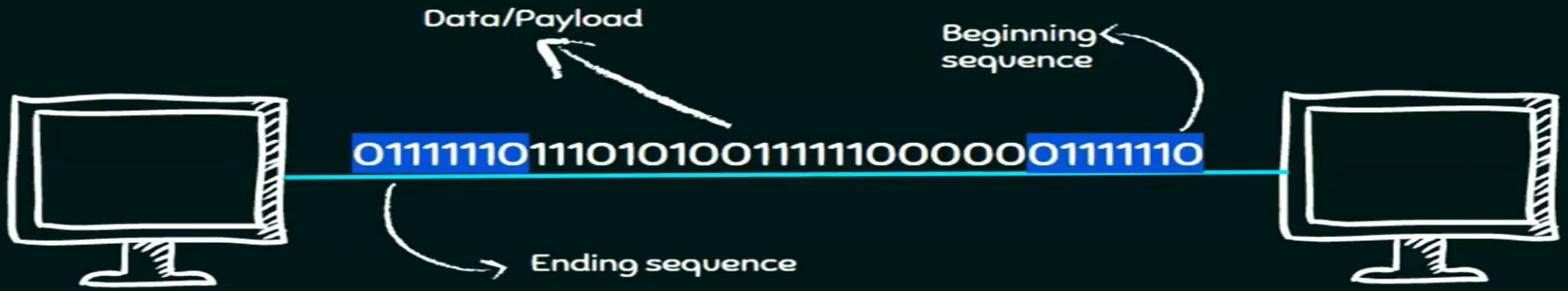
★ Checksum – Error detection.

Bit Stuffing

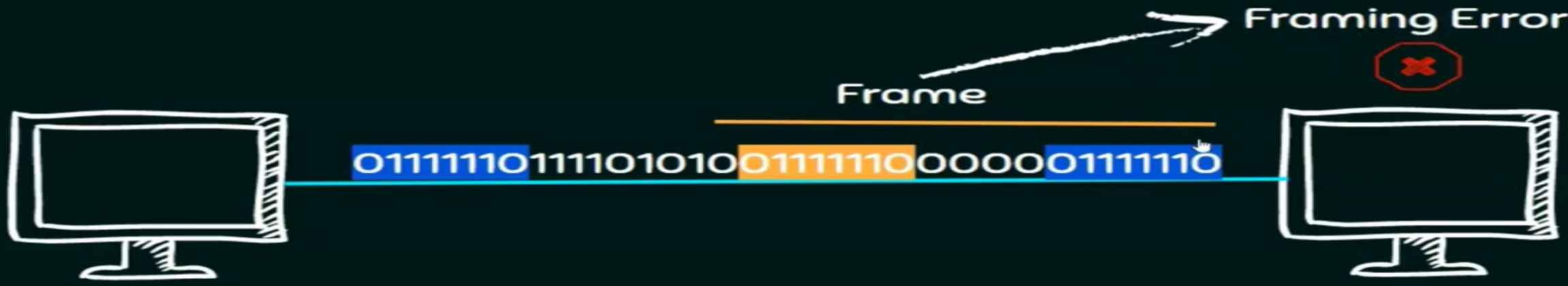


HDLC Protocol: Beginning and Ending Sequence is 01111110

PROBLEM HERE...



Problem



HDLC Protocol: Beginning and Ending Sequence is 01111110

Bit stuffing

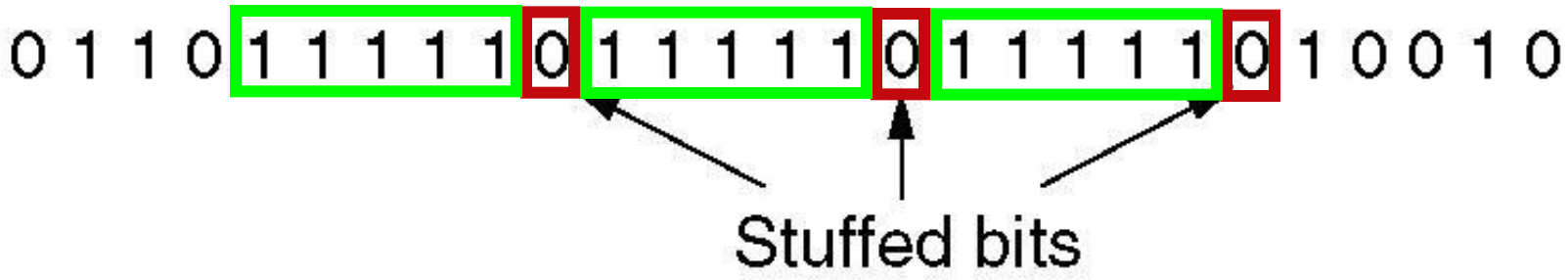
HDLC Protocol: Beginning and Ending Sequence is 01111110

Framing Based on Bit Stuffing: Example

Original Frame (payload only)

0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0

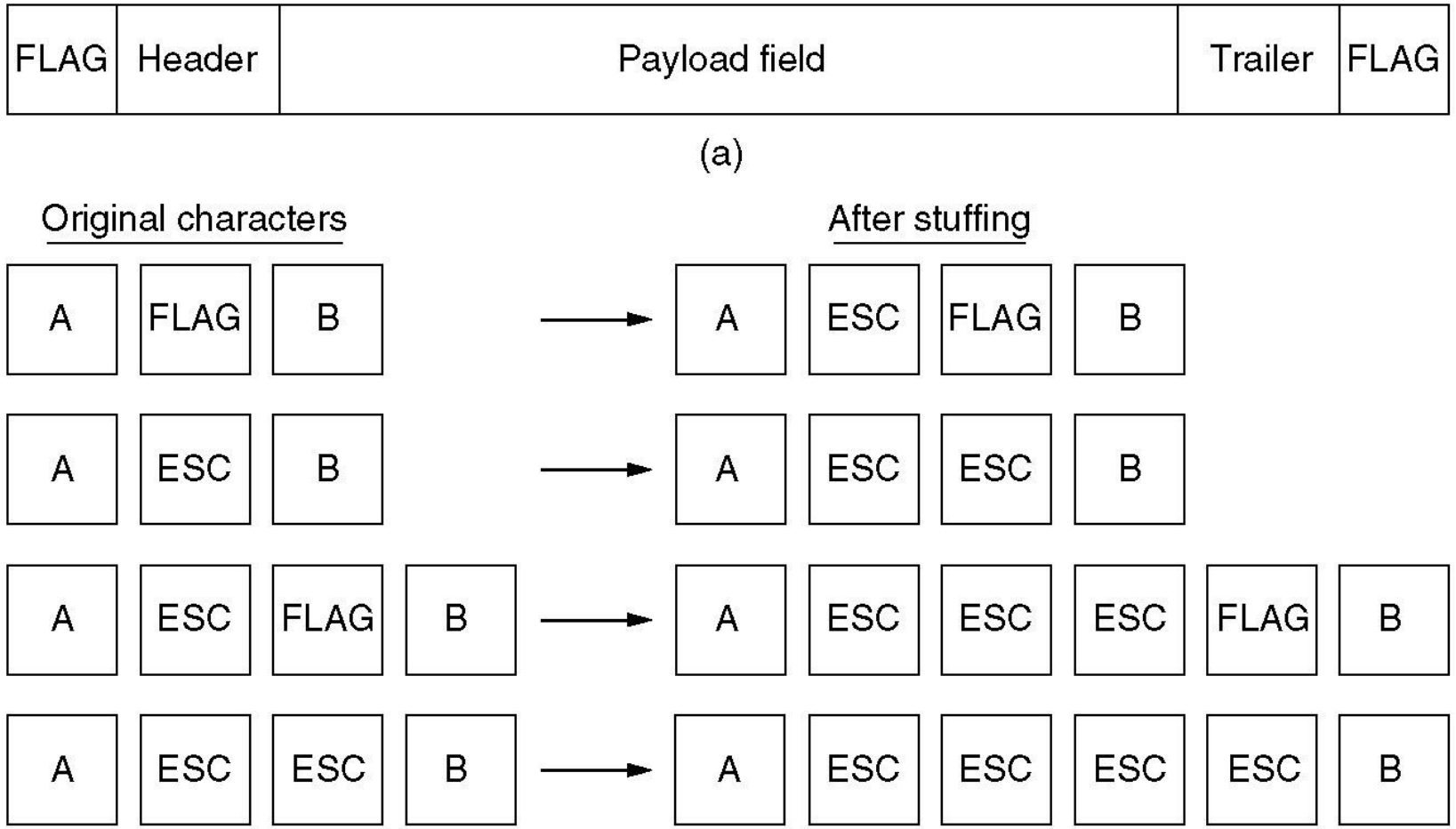
Frame after bit stuffing



Received Frame after taken stuffed bit out

Character stuffing

Byte stuffing or Character stuffing is the process of adding one extra byte whenever there is a flag sequence appear in the payload.



Flow control

- ★ Speed matching mechanism.
- ★ Flow control coordinates the amount of data that can be sent before receiving an acknowledgment.
- ★ Flow control is a set of procedures that tells the sender how much data it can transmit before it must wait for an acknowledgement from the receiver.
- ★ Receiver has a limited speed at which it can process incoming data and a limited amount of memory in which to store incoming data.
- ★ Receiver must inform the sender before the limits are reached and request that the transmitter to send fewer frames or stop temporarily.

Flow control – Protocols

Stop-and-Wait Protocol

- ★ Stop - and - Wait protocol is data link layer protocol for transmission of frames over noiseless channels.
- ★ It provides unidirectional data transmission with flow control facilities but without error control facilities.
- ★ The idea of stop-and-wait protocol is straightforward.
- ★ After transmitting one frame, the sender waits for an acknowledgement before transmitting the next frame.

Primitives of Stop-and-Wait Protocol

Sender side

Rule 1 : Send one data Frame at a time.

Rule 2 : Send the next Frame only after receiving ACK for the previous.

Receiver side

Rule 1 : Receive and consume data Frame.

Rule 2 : After consuming Frame, ACK need to be sent (Flow Control).

Problems of Stop-and-Wait Protocol

1. Problems due to lost data.

   Sender waits for ack for an infinite amount of time.

   Receiver waits for data an infinite amount of time.

2. Problems due to lost ACK.

   Sender waits for an infinite amount of time for ack.

3. Problems due to delayed ACK/data.

   After timeout on sender side, a delayed ack might be wrongly considered as ack of some other data

Frame

Stop-and-Wait ARQ Protocol

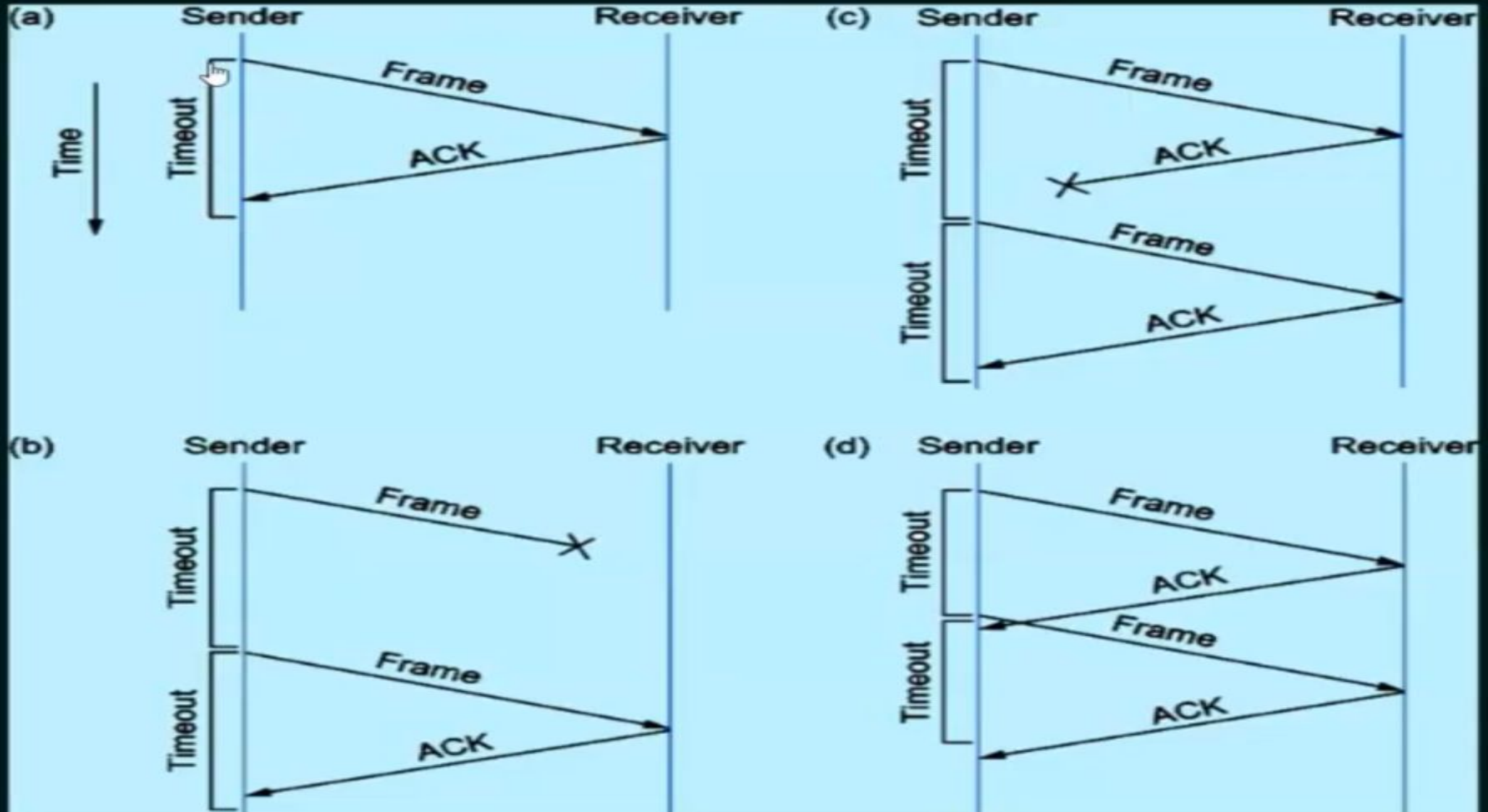
★ Idea of stop-and-wait protocol is straightforward.

★ After transmitting one frame, the sender waits for an acknowledgement before transmitting the next frame.

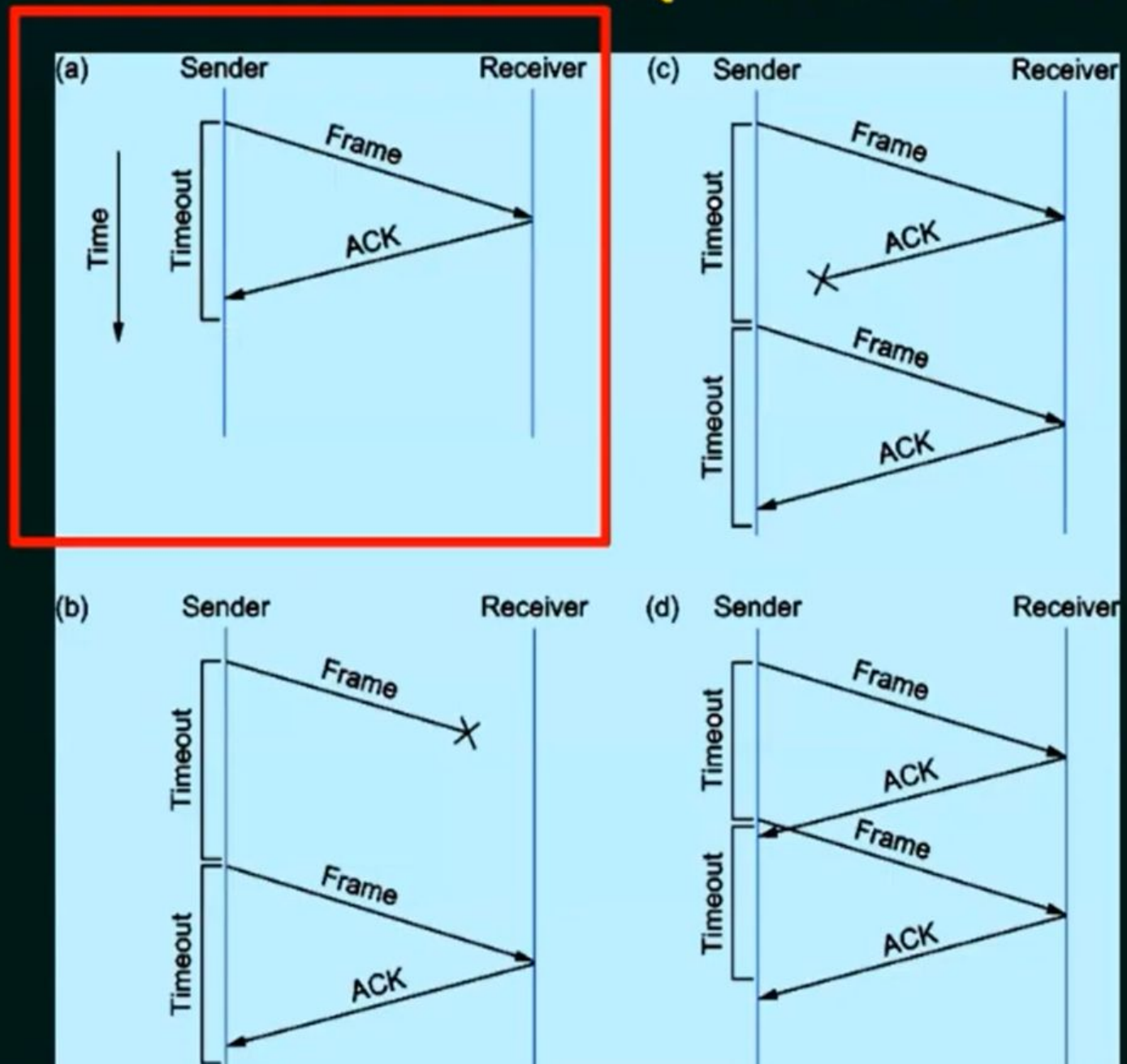
★ If the acknowledgement does not arrive after a certain period of time, the sender times out and retransmits the original frame.

★ Stop-and-Wait ARQ = Stop-and-Wait + Timeout Timer + Sequence number

Stop-and-Wait ARQ Protocol

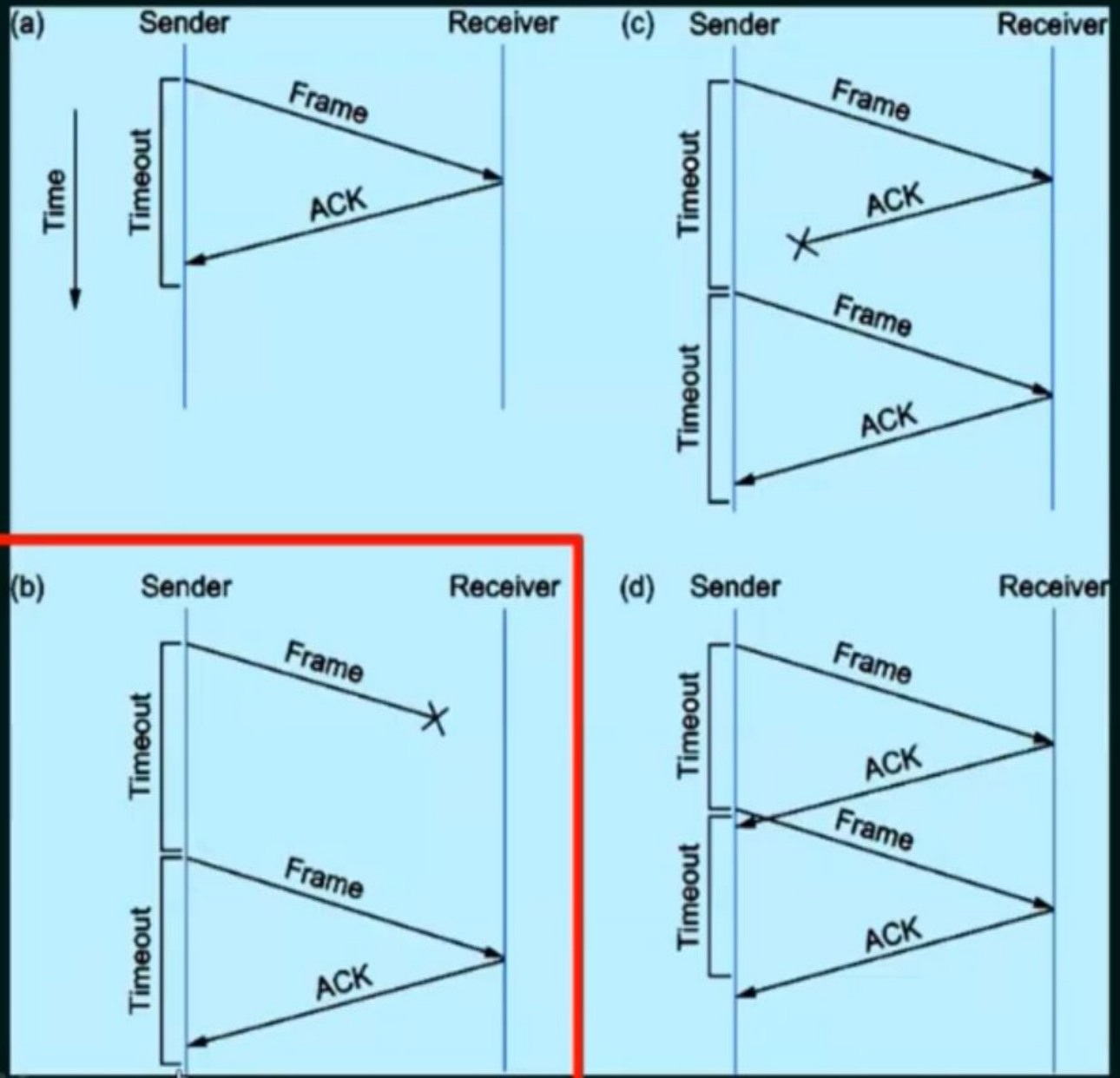


Stop-and-Wait ARQ Protocol



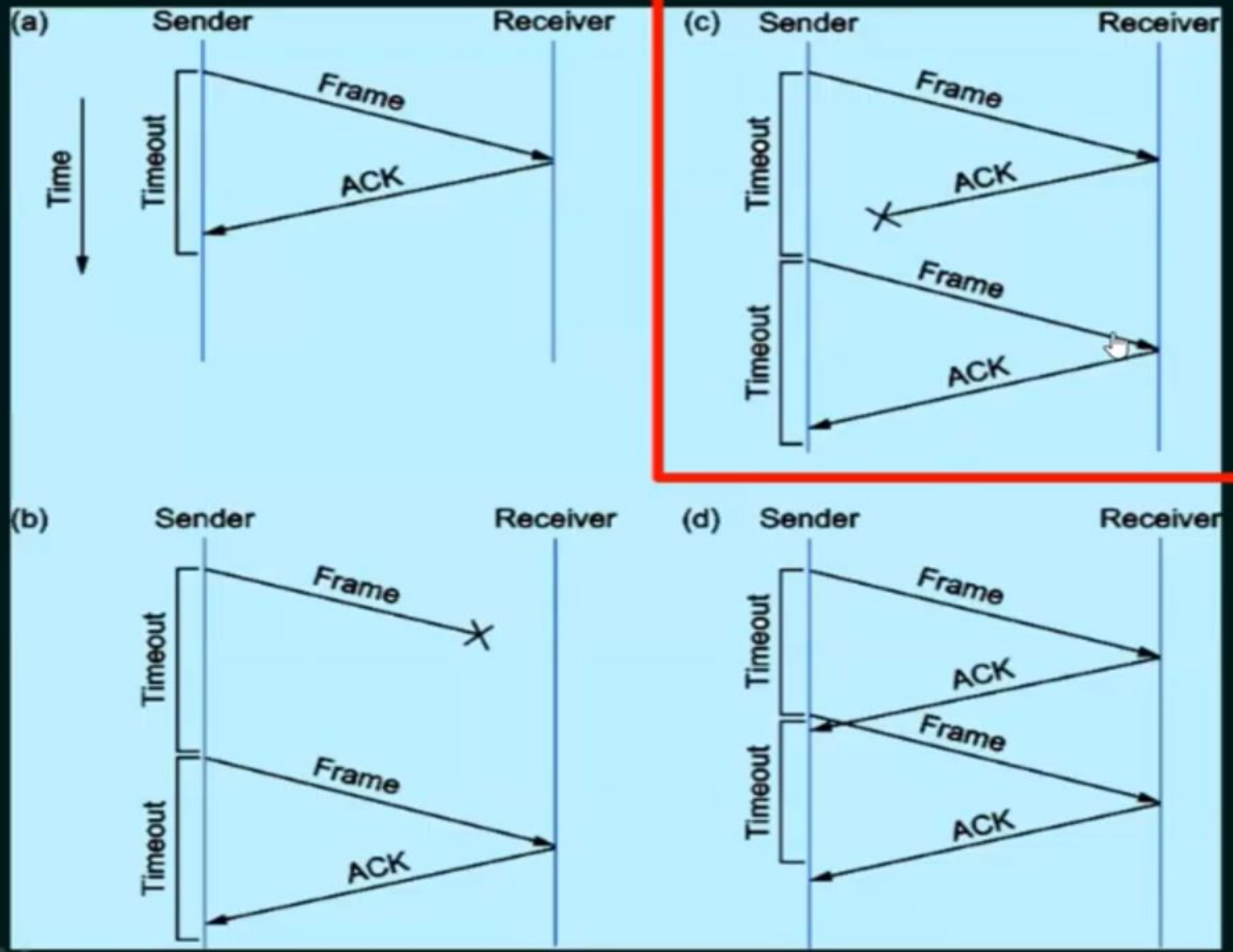
(a) The ACK is received before the timer expires;

Stop-and-Wait ARQ Protocol



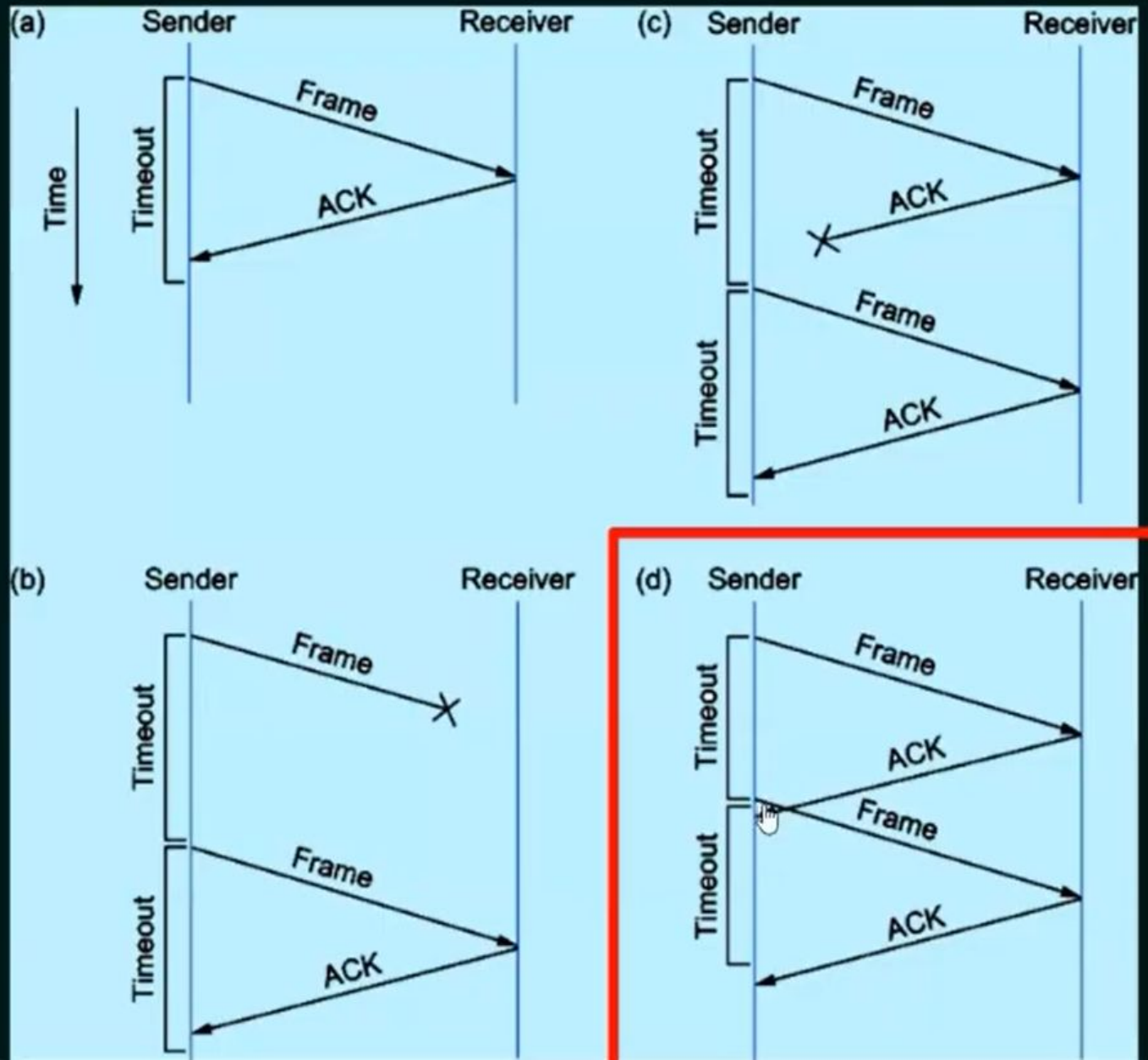
(b) The original frame is lost

Stop-and-Wait ARQ Protocol



(c) The ACK is lost

Stop-and-Wait ARQ Protocol



(d) The timeout fires too soon

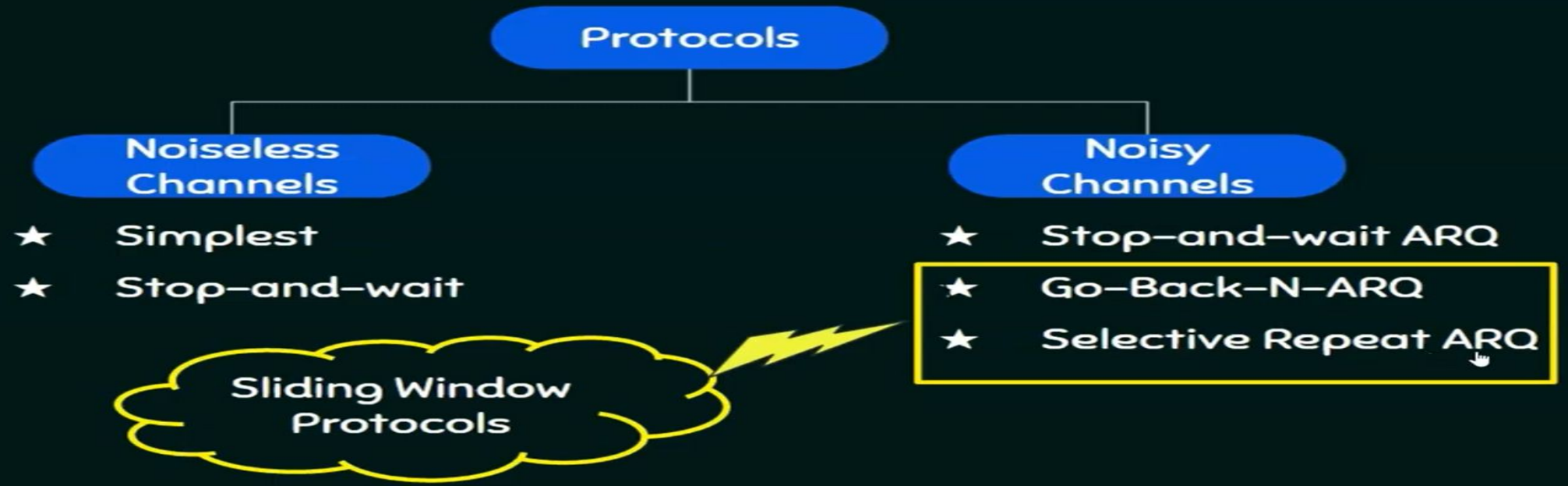
Stop-and-Wait ARQ - Drawbacks

- ★ One frame at a time.
- ★ Poor utilization of bandwidth.
- ★ Poor Performance

SLIDING WINDOW PROTOCOL

- ★ Send multiple frames at a time.
- ★ Number of frames to be sent is based on Window size.
- ★ Each frame is numbered -> Sequence number.

FLOW CONTROL



Working of Sliding Window Protocol

Window Size: 4

Sender

Receiver

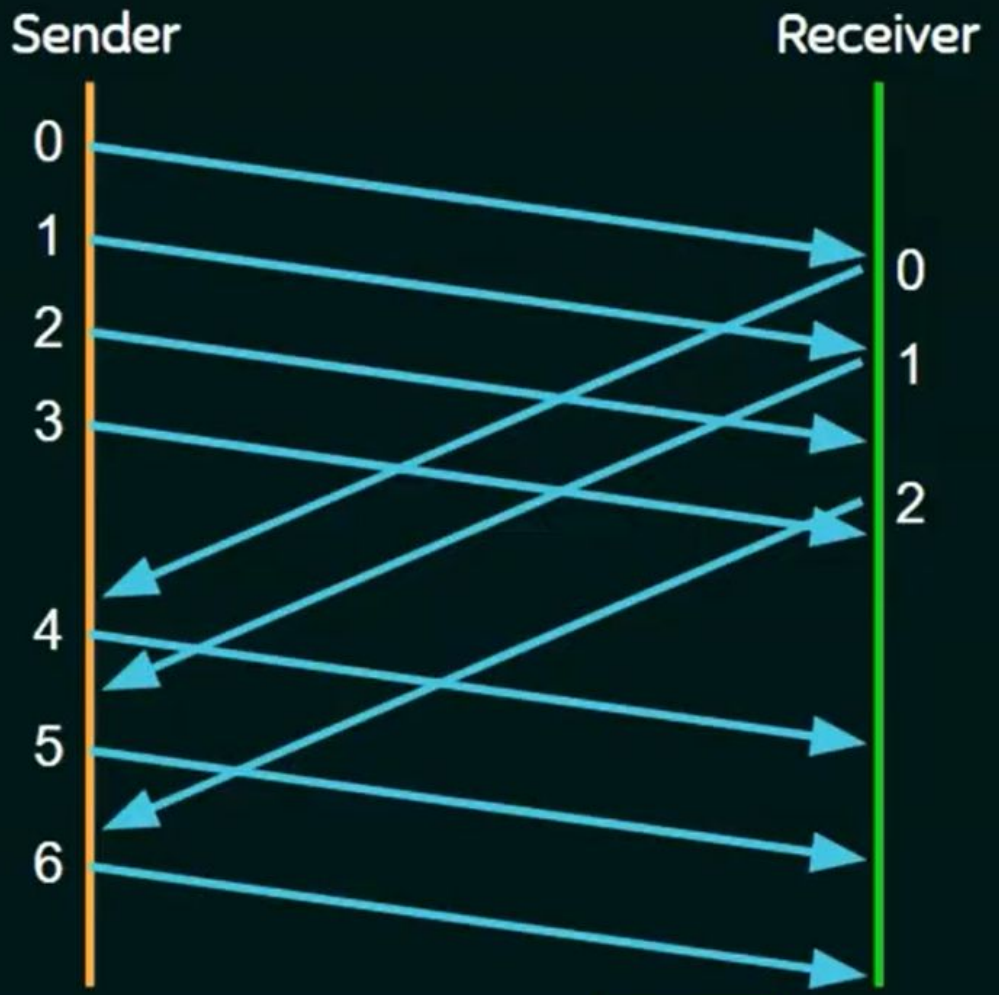
Working of Sliding Window Protocol

Sliding Window

Not Yet Sent

Sent but not acknowledged

Already Sent and Acknowledged



Window Size: 4

Go-Back-N ARQ

- ★ Go - Back - N ARQ uses the concept of protocol pipelining i.e. the sender can send multiple frames before receiving the acknowledgment for the first frame.
- ★ There are finite number of frames and the frames are numbered in a sequential manner.
- ★ The number of frames that can be sent depends on the window size of the sender.
- ★ If the acknowledgment of a frame is not received within an agreed upon time period, all frames in the current window are transmitted.

Go-Back-N ARQ

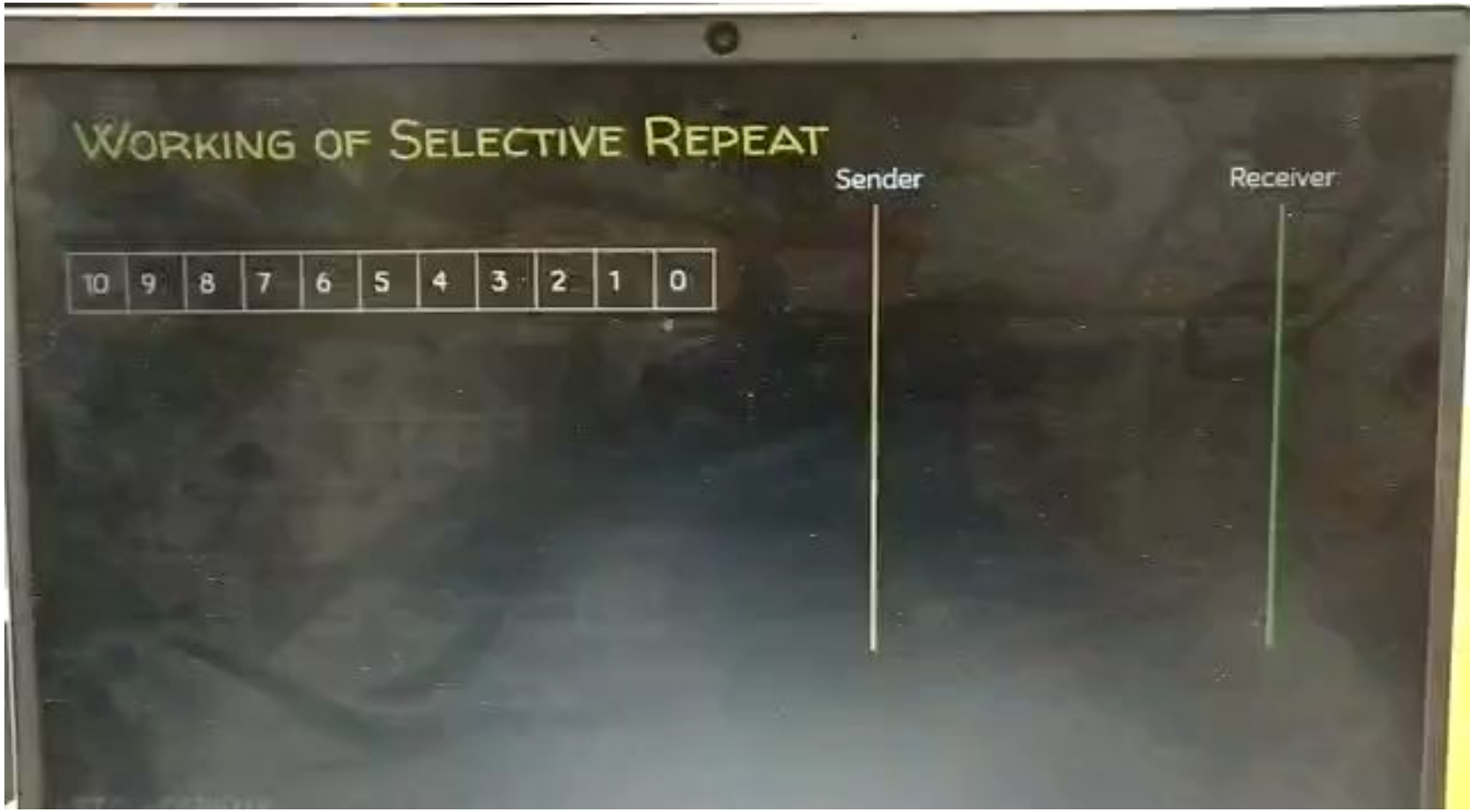
- ★ N - Sender's Window Size.
- ★ For example, if the sending window size is 4 (2^2), then the sequence numbers will be 0, 1, 2, 3, 0, 1, 2, 3, 0, 1, and so on.
- ★ The number of bits in the sequence number is 2 to generate the binary sequence 00, 01, 10, 11.

Working example

Selective Repeat ARQ

- ★ In Selective Repeat ARQ, only the erroneous or lost frames are retransmitted, while correct frames are received and buffered.
- ★ 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 will send/retransmit packet for which NACK is received.

Working of Select Repeat ARQ



Question 1:

- Station A needs to send a message consisting of 9 frames to station B

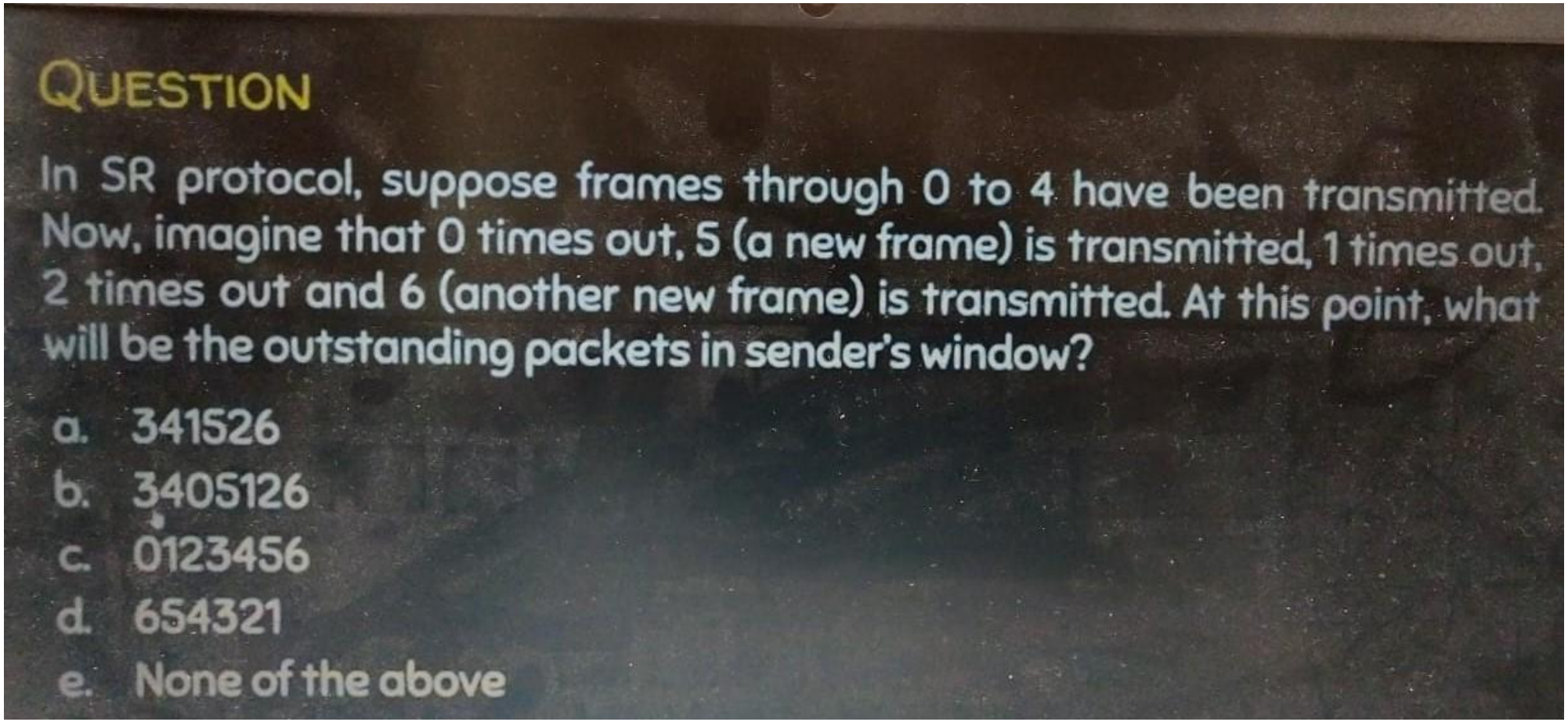
Using a sliding window (window size is 3)and go –back-n error control strategy . All the frames are ready and immediately available for transmission. If every 5^{th} frame that A transmits get lost, then what is the number of frames that A will transmit for sending the message to B?

Question 2

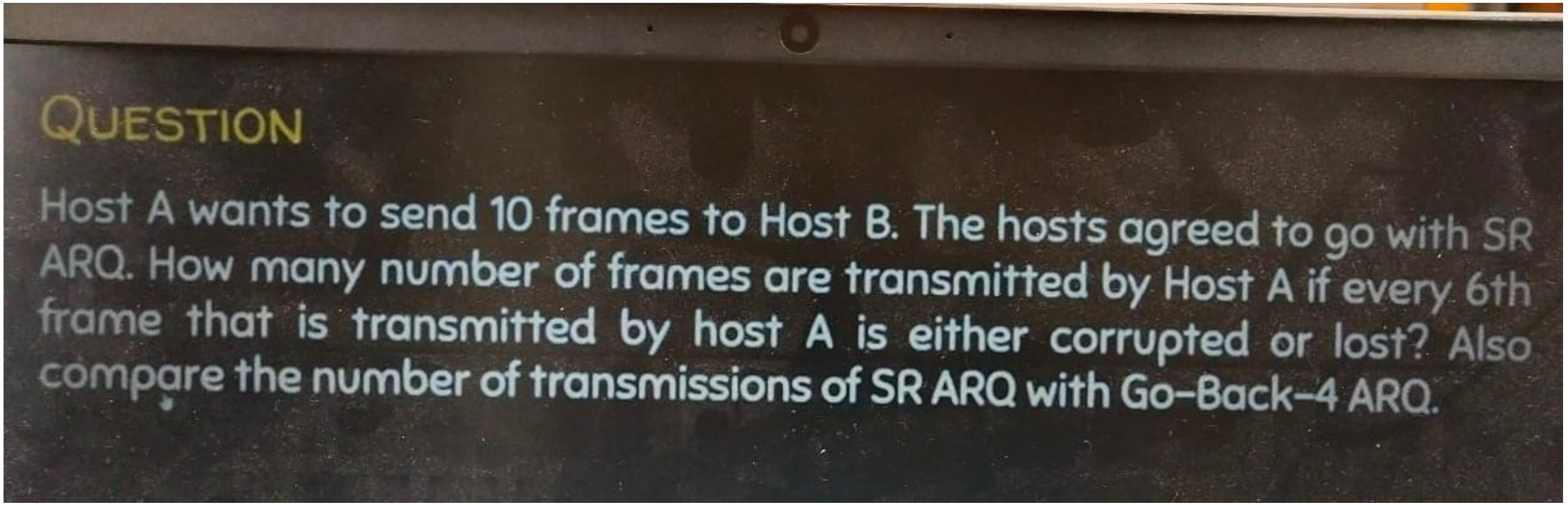
- Host A wants to send 10 frames to host B. The hosts agreed to go with Go-Back-4 .How many number of frames are transmitted by host A if every 6^{th} frame that is transmitted by host A is either corrupted or lost?

14

Question 3


QUESTION
In SR protocol, suppose frames through 0 to 4 have been transmitted. Now, imagine that 0 times out, 5 (a new frame) is transmitted, 1 times out, 2 times out and 6 (another new frame) is transmitted. At this point, what will be the outstanding packets in sender's window?
a. 341526
b. 3405126
c. 0123456
d. 654321
e. None of the above

Question 4



SR - 11GO- Back