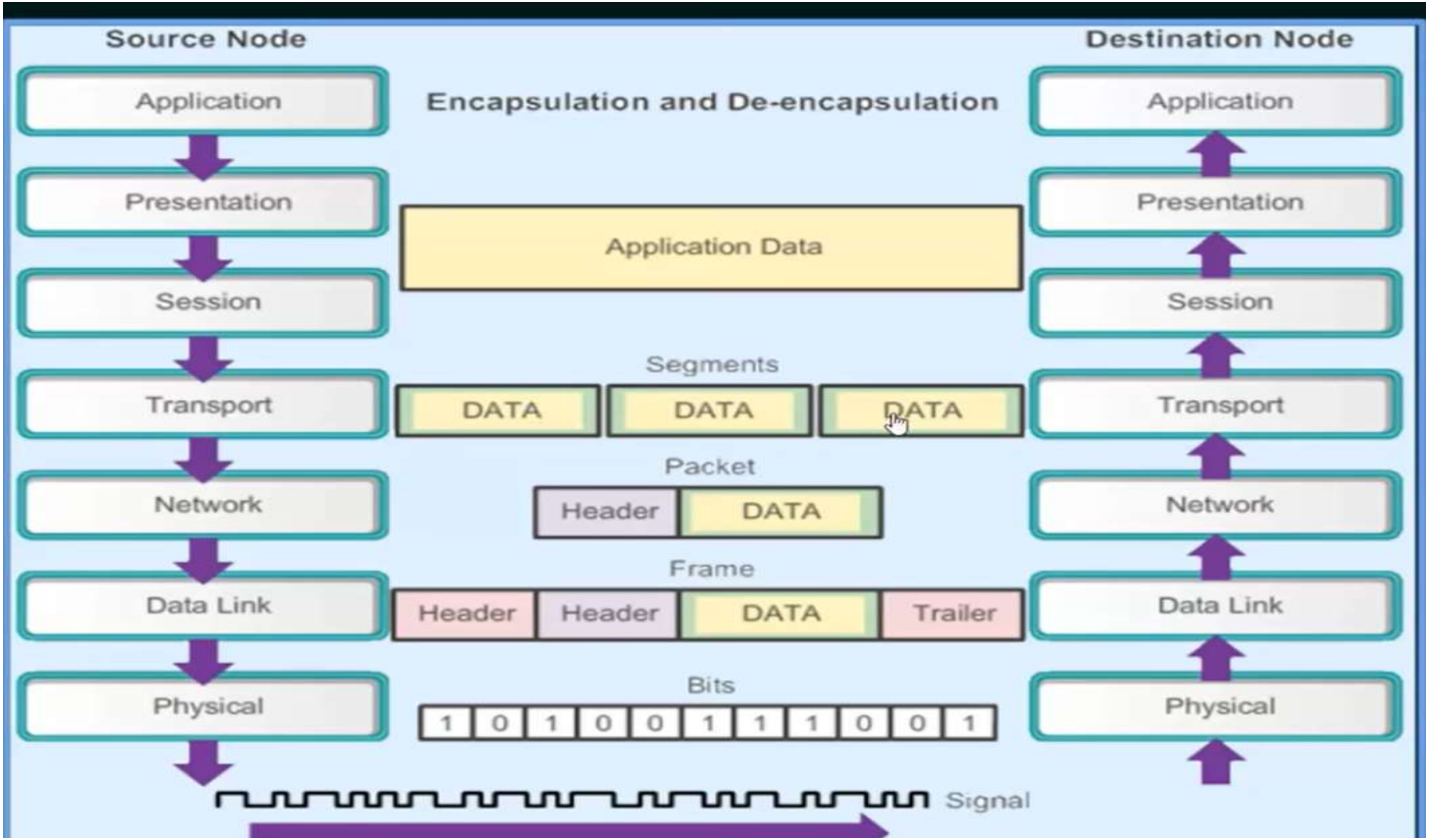

Source Node
Destination Node
Application
Presentation
Session
Transport
Network
Data Link
Physical
Encapsulation and De-encapsulation
Application Data
Segments
DATA
DATA
DATA
Packet
Header
DATA
Frame
Header
Header
DATA
Trailer
Bits
1 0 1 0 0 1 1 1 0 0 1
Signal

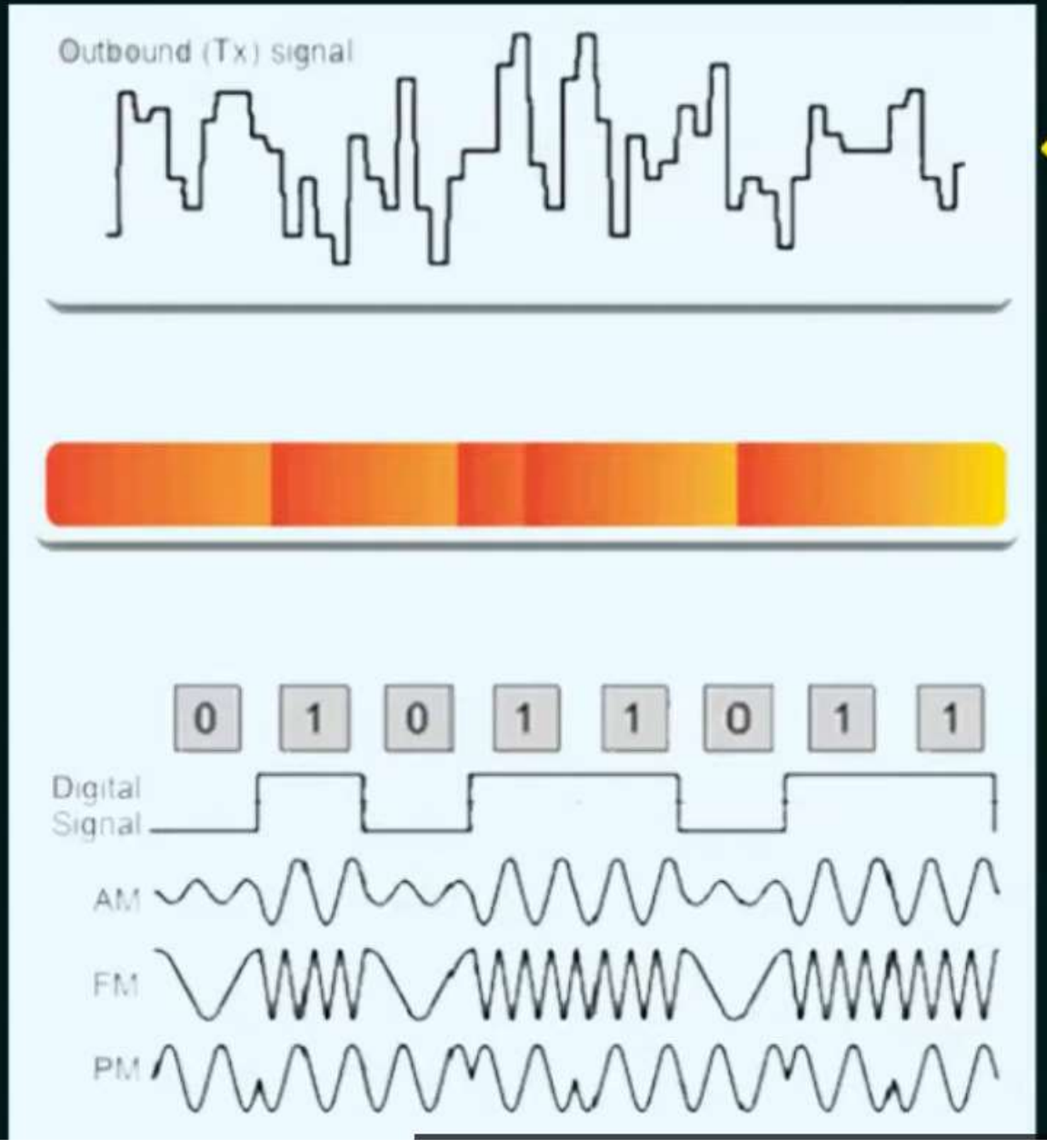
# Fundamental principles of physical Layer

- ★ One of the major functions of the physical layer is to move data in the form of electromagnetic signals across a transmission medium.
- ★ The data usable to a person or an application are not in a form that can be transmitted over a network.
- ★ For example, an image must first be changed to a form that transmission media can accept.
- ★ To be transmitted, data must be transformed to electromagnetic signals.

# Signal

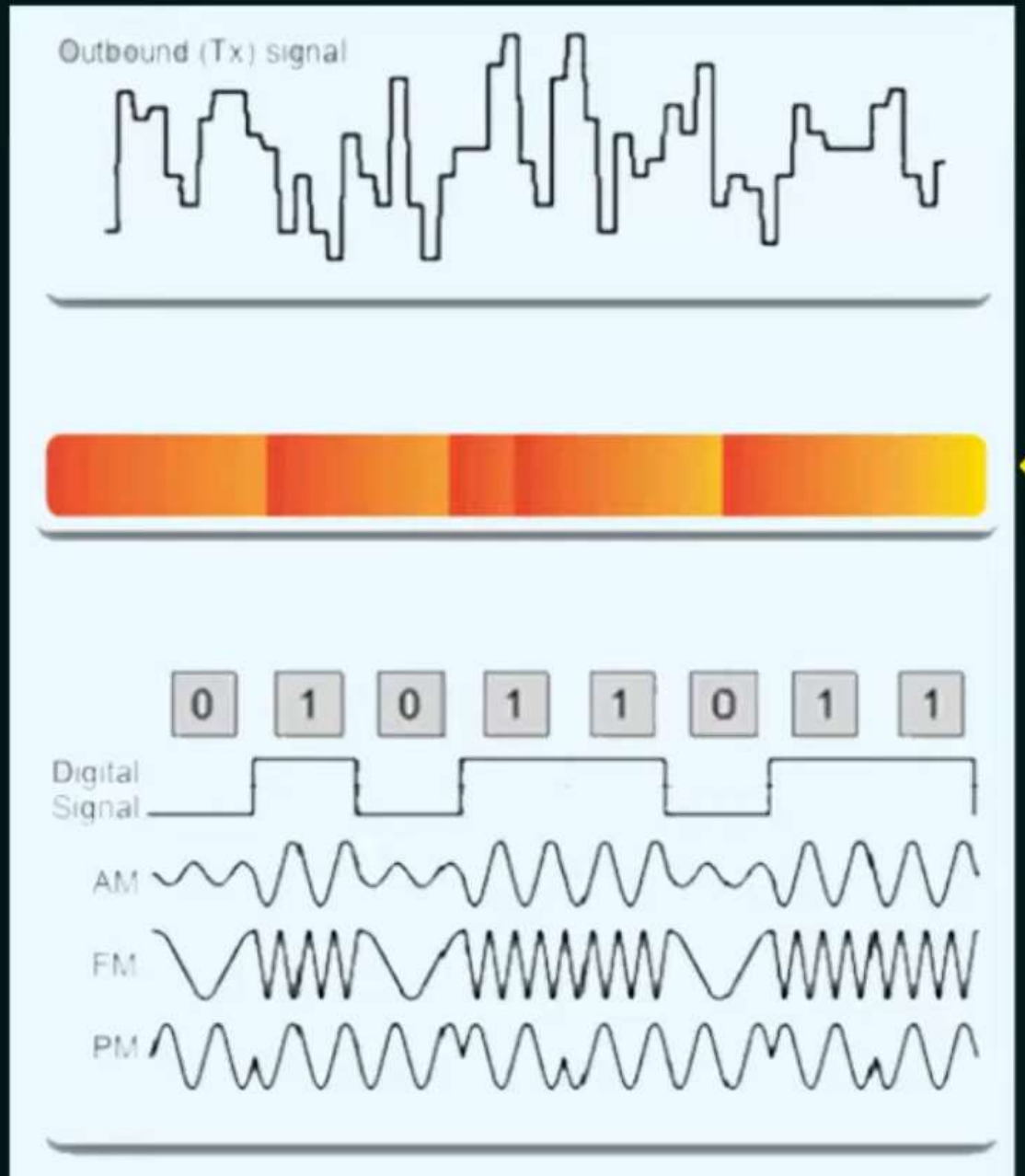
★ It is a function that represents the variation of a physical quantity with respect to time.

# Physical Layer Media



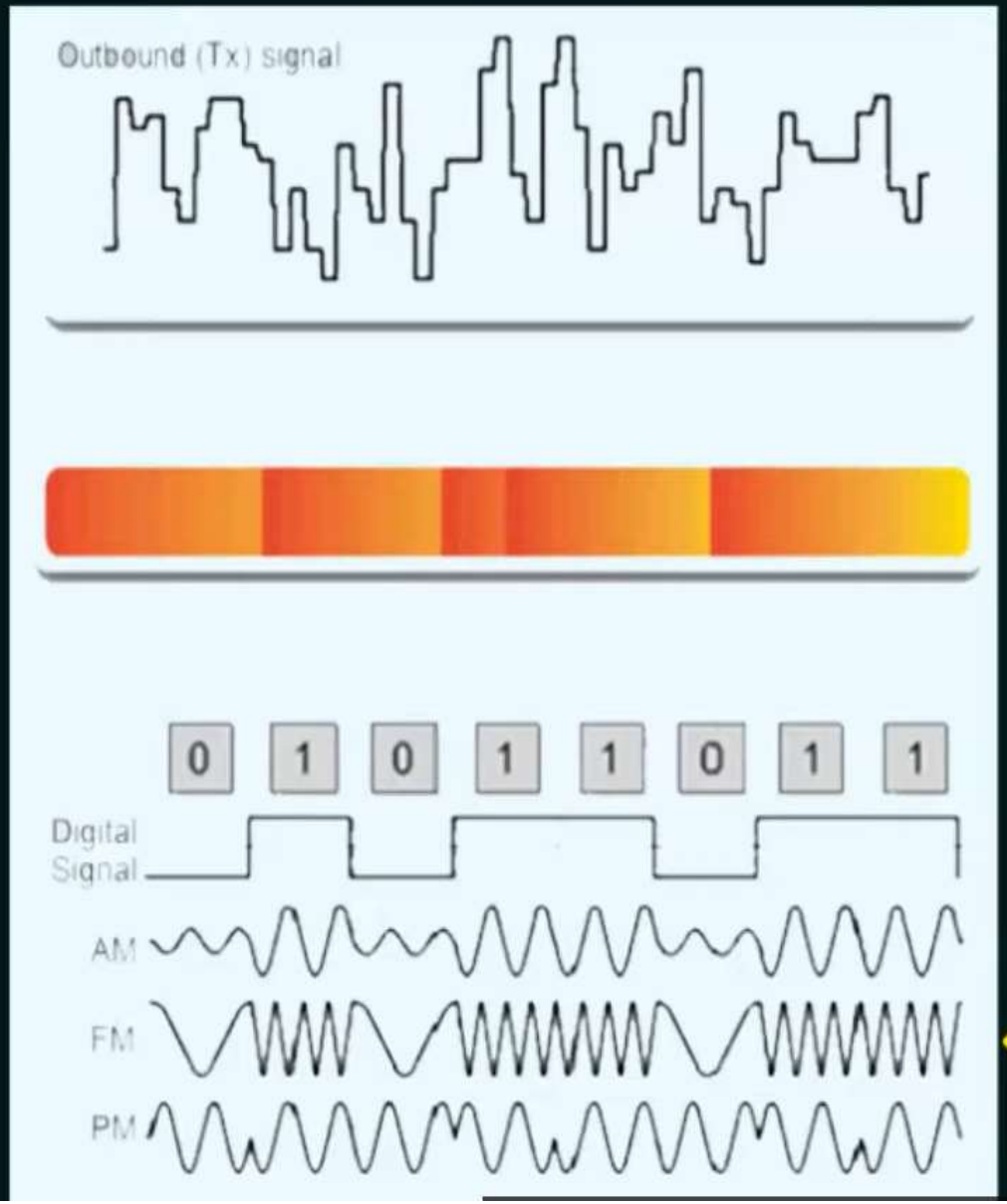

Electrical Signals
Copper cable

# Physical Layer Media




Light pulses
Fibre Optic cable

# Physical Layer Media




Microwave signals
Wireless

# Comparison of various physical media

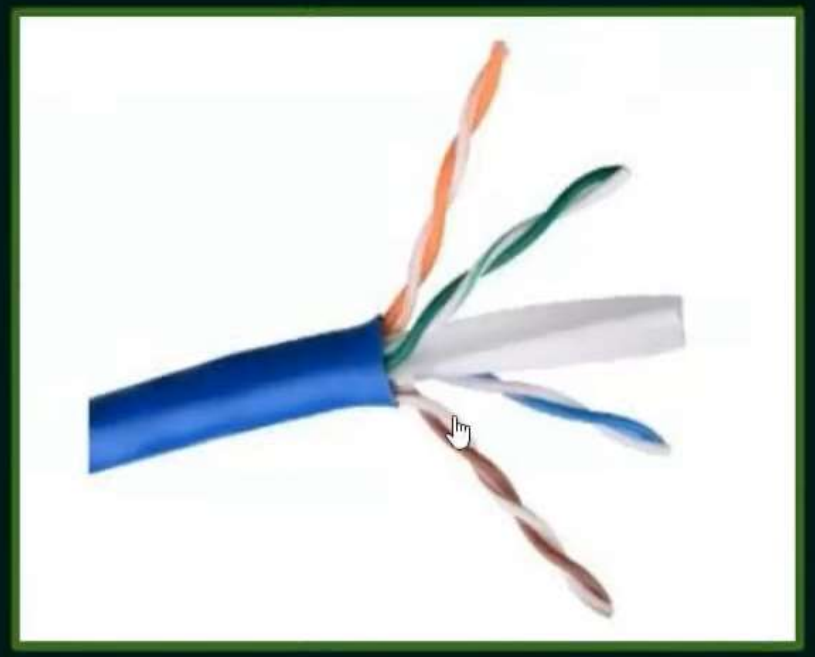
| Media | Physical Components | Signal |
| --- | --- | --- |
| Copper Cable (Wired) | ·UTP/STP<br>·Coaxial<br>·Connectors<br>·NICs<br>·Ports/·Interfaces | Electromagnetic Signal |
| Fiber Optic Cable (Wired) | ·Single-mode Fiber<br>·Multimode Fiber<br>·Connectors<br>·NICs and Interfaces<br>·Lasers and LEDs | ·A light pulse equals 1.<br>·No light pulse is 0. |
| Wireless Media | ·Access Points<br>·NICs<br>·Radio<br>·Antennae | ·Radio waves |

# Wired media

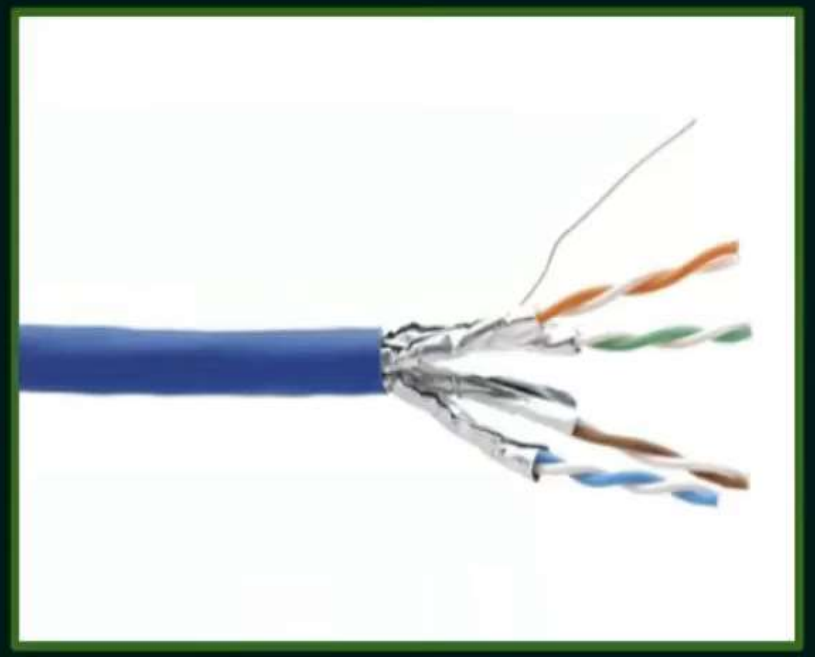
- ★ Copper cable (Ethernet cable)
  - Unshielded Twisted Pair (UTP).
  - Shielded Twisted Pair (STP).

# Copper media – Ethernet

# Copper media – Ethernet

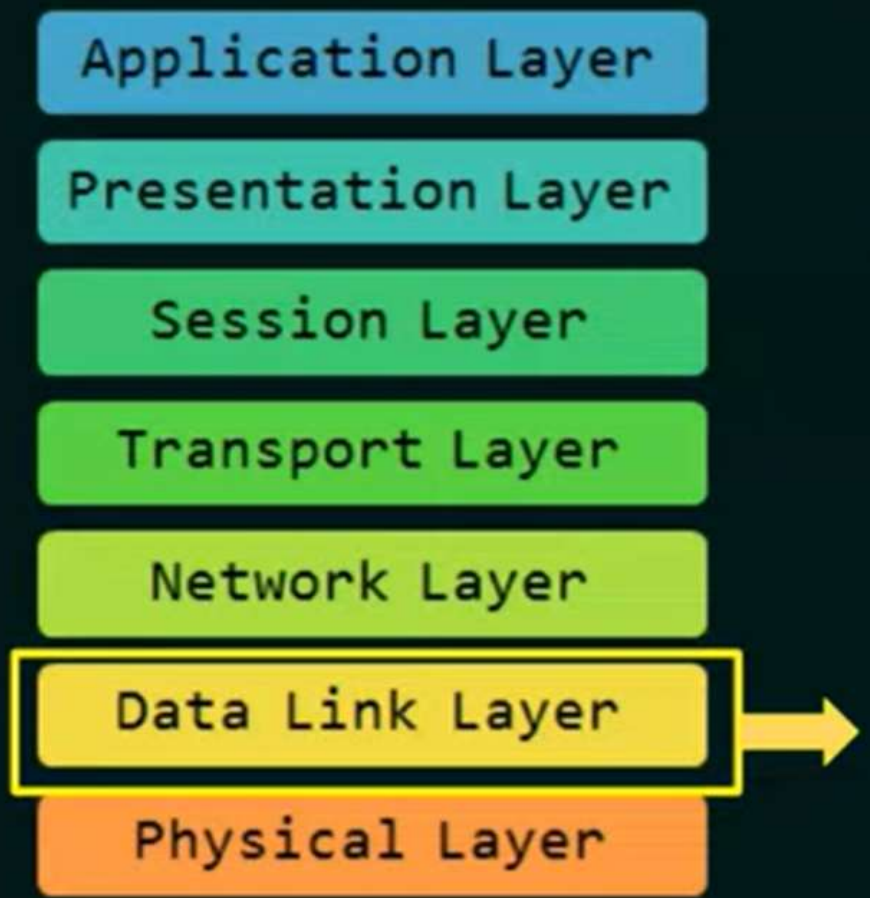


Unshielded Twisted Pair (UTP)
Ethernet Cable



Shielded Twisted Pair (STP)
Ethernet cable

# DATA LINK LAYER



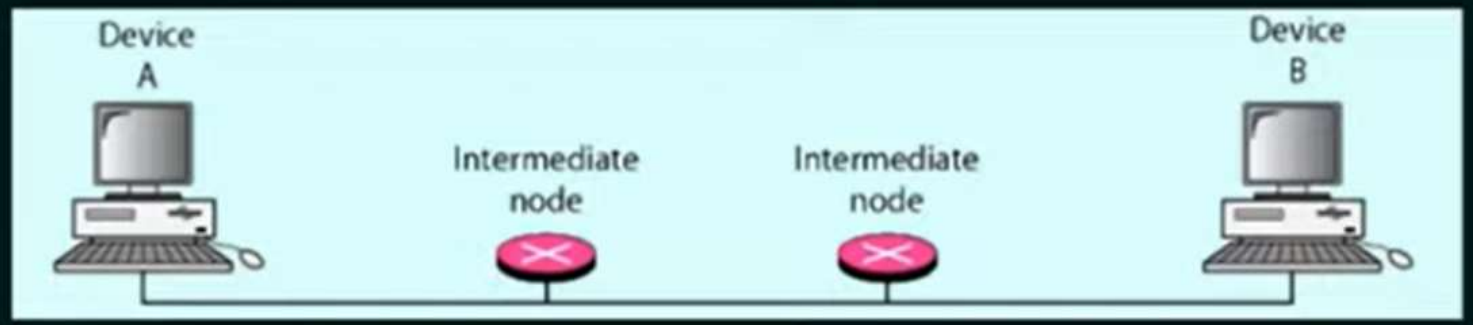

It is responsible for moving data(frames) from one node to another node.

SERVICES PROVIDED BY DATA LINK LAYER

- ★ Framing.
- ★ Physical Addressing.
- ★ Flow Control.
- ★ Error Control.
- ★ Access Control.

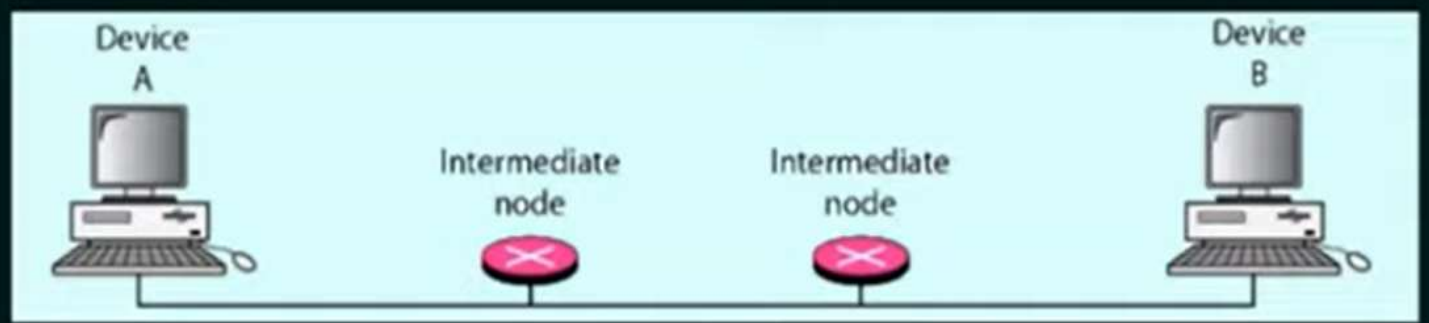
# FRAMING

- ★ The data link layer needs to pack bits into frames, so that each frame is distinguishable from another.
- ★ Our postal system practices a type of framing.
- ★ The simple act of inserting a letter into an envelope separates one piece of information from another; the envelope serves as the delimiter.



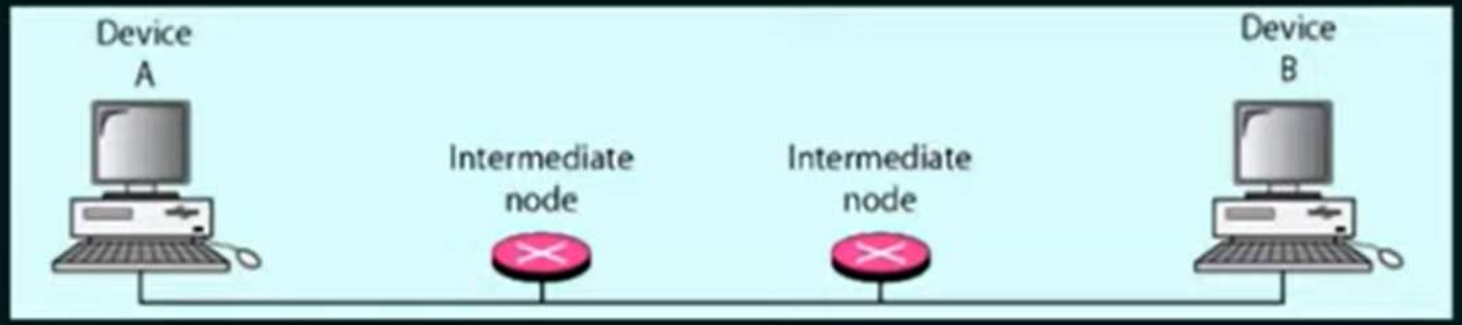
# Physical Addressing

- ★ A Frame is the encapsulation of the header and trailer information with the packet.
- ★ In the header, the source and the destination MAC address are dealt.



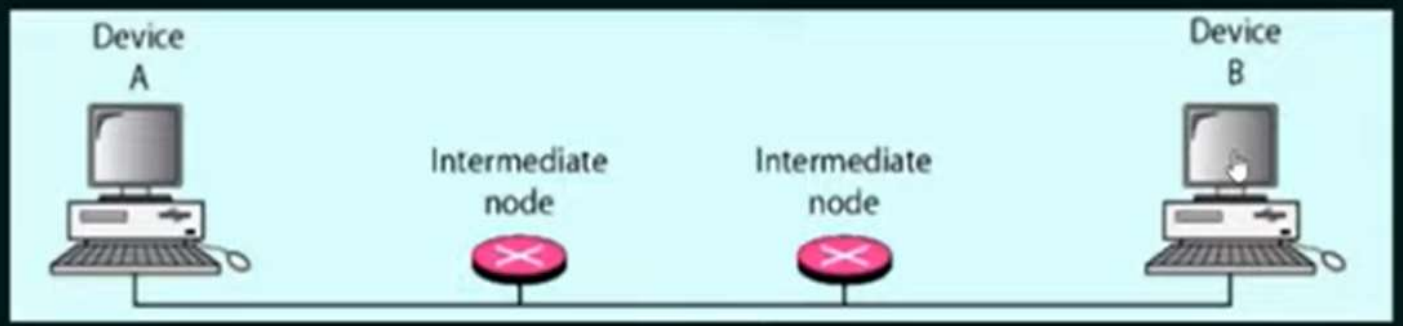
# Flow control

- ★ Flow Control is one of the duties of data link control sublayer.
- ★ The flow control in data link layer is end to end flow control.
- ★ Speed matching mechanism.
- ★ Flow control coordinates the amount of data that can be sent before receiving an acknowledgment.



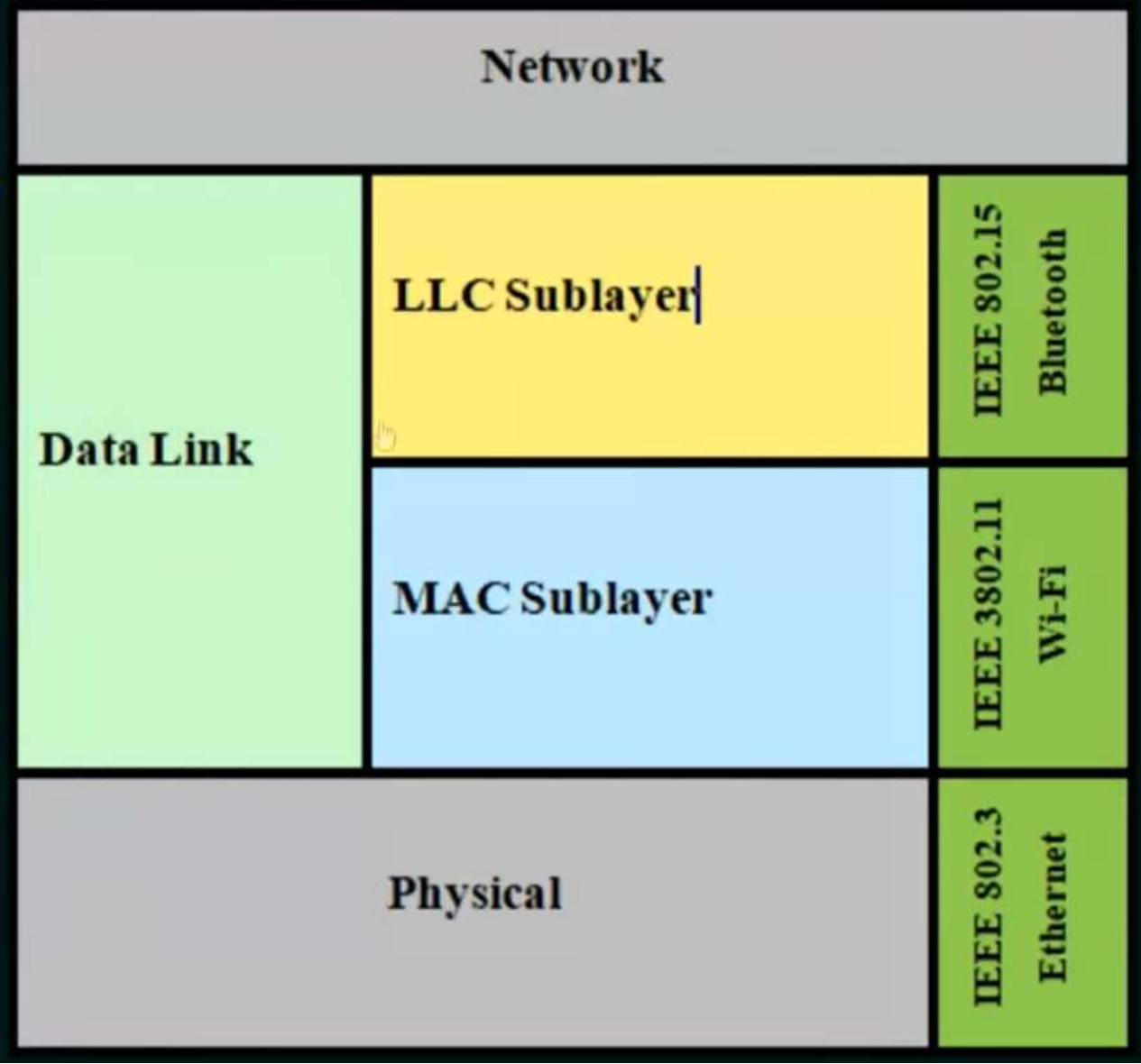
# Error control

- ★ Error Detection.
- ★ Error Correction.



# Data Link Layer

- Application Layer
- Presentation Layer
- Session Layer
- Transport Layer
- Network Layer
- Data Link Layer
- Physical Layer



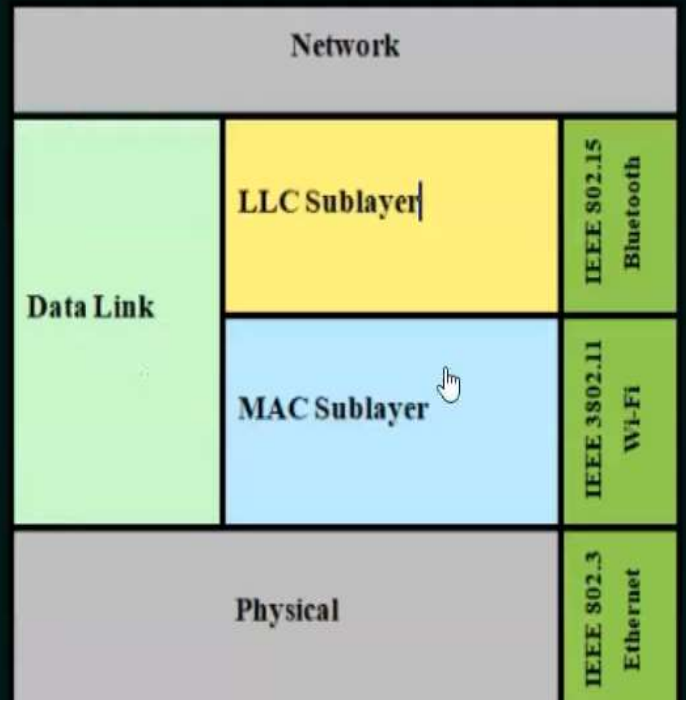
# Data Link sublayers

## Logical Link Control (LLC) or Data Link Control (DLC) Sublayer

- ★ Handles communication between upper and lower layers.
- ★ Takes the network protocol data and adds control information to help deliver the packet to the destination. (Flow control)

## MAC Sublayer

- ★ Constitutes the lower sublayer of the data link layer.
- ★ Implemented by hardware, typically in the computer NIC.
- ★ Two primary responsibilities:
  - ★ Data encapsulation
  - ★ Media access control



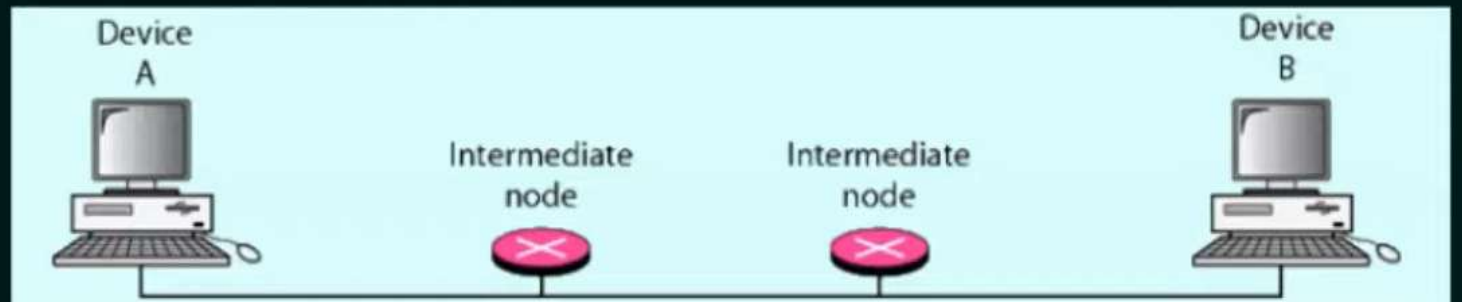
# MAC SUBLAYER

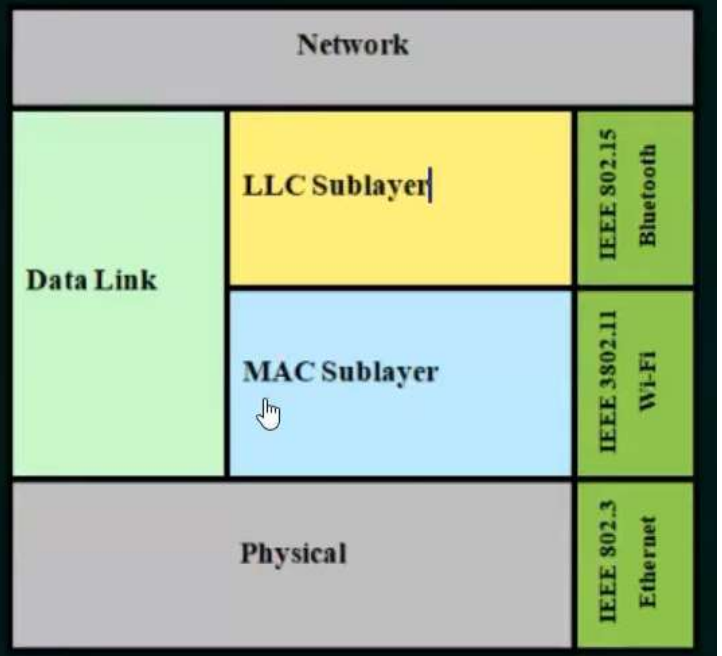
## Data encapsulation

- ★ Frame assembly before transmission and frame disassembly upon reception of a frame.
- ★ MAC layer adds a header and trailer to the network layer PDU.

## Provides three primary functions:

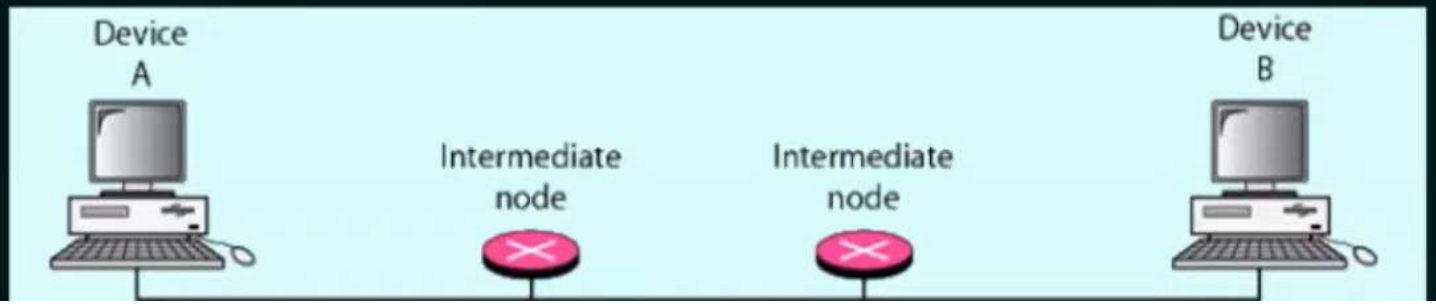
- ★ Framing.
- ★ Physical Addressing or MAC Addressing.
- ★ Error control.

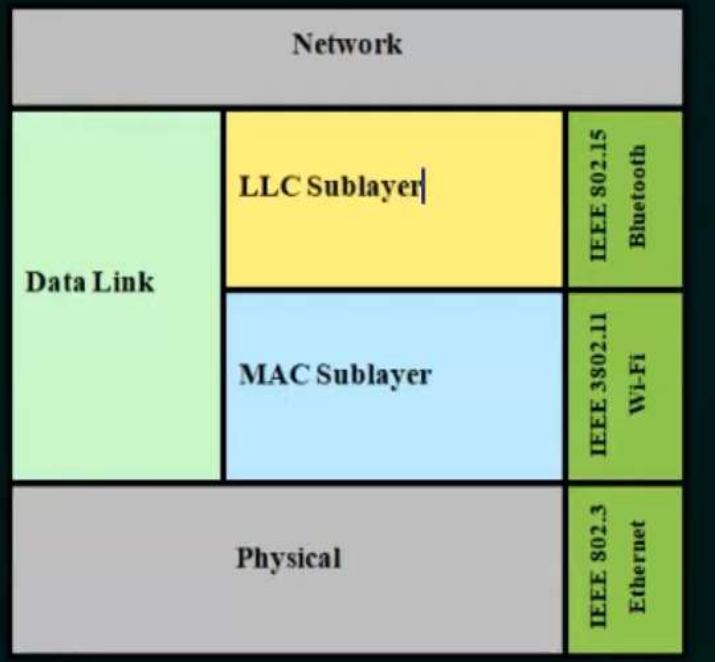


# MAC SUBLAYER

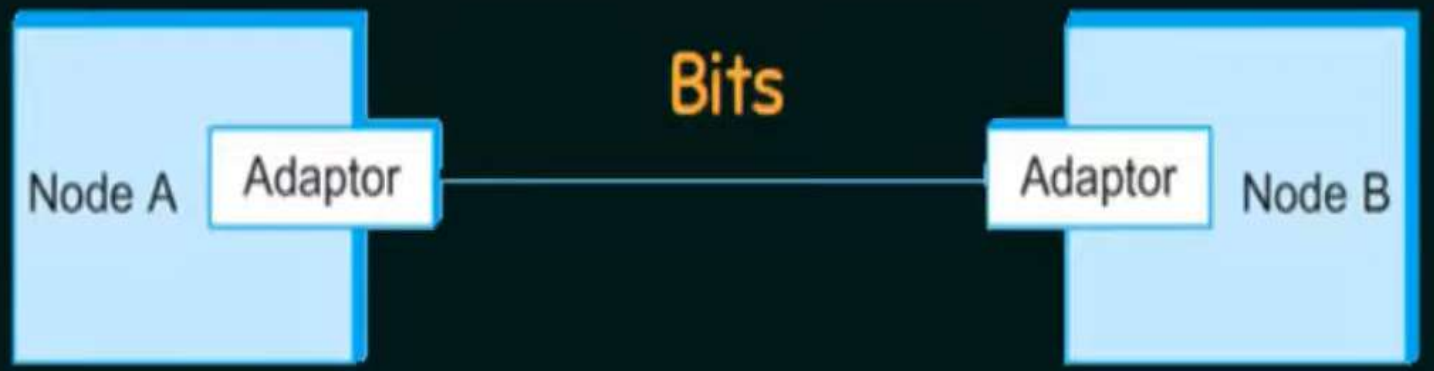
- ★ Responsible for the placement of frames on the media and the removal of frames from the media
- ★ Communicates directly with the physical layer.



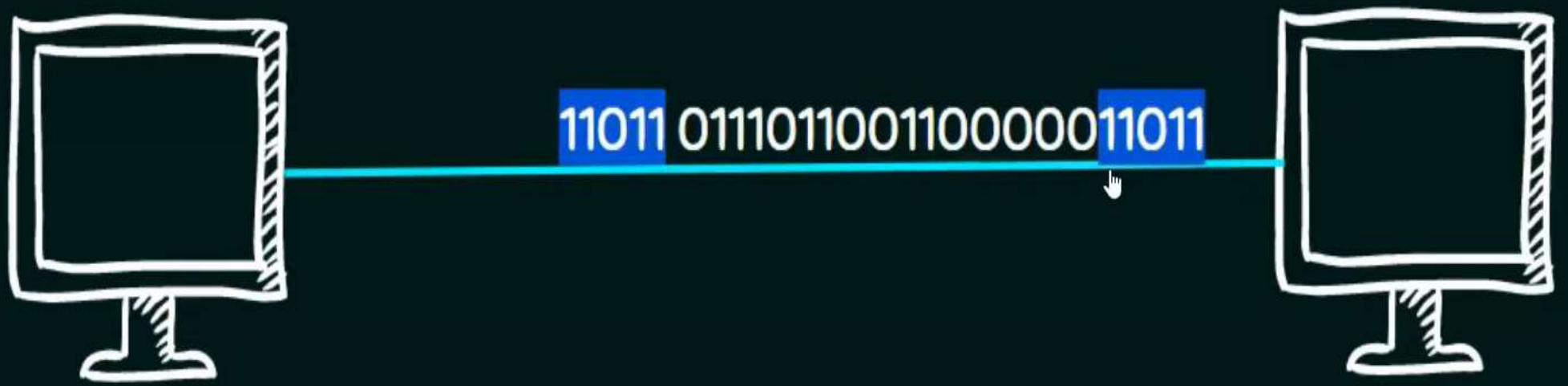
| Service | Sublayer |
| --- | --- |
| Flow Control | LLC or DLC |
| Framing | MAC |
| Physical Addressing | MAC |
| Error Control | MAC |
| Access Control | MAC |

# Framing



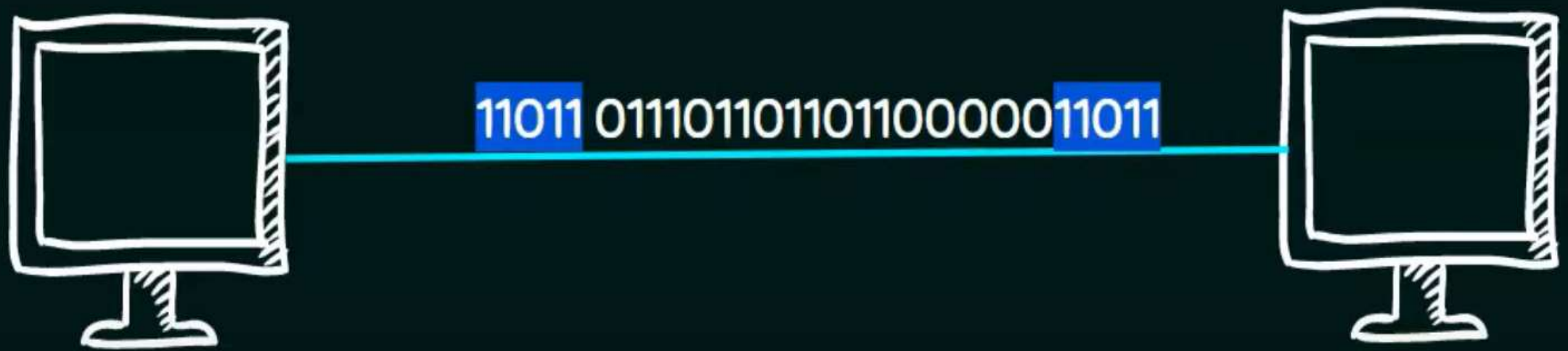

Bits flow between adaptors, frames between hosts

# Framing



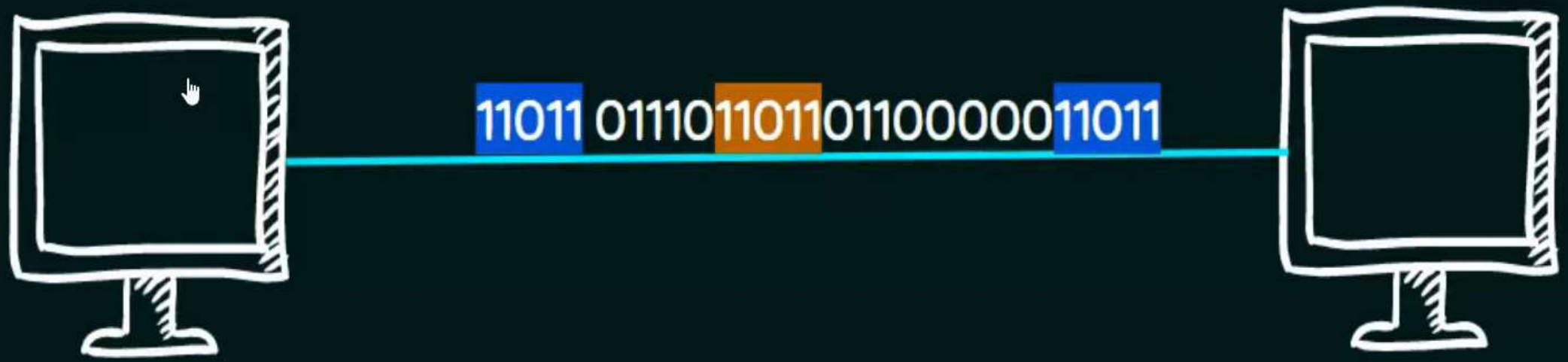

Let the start of frame and end of frame be 11011

# ANY PROBLEM HERE...



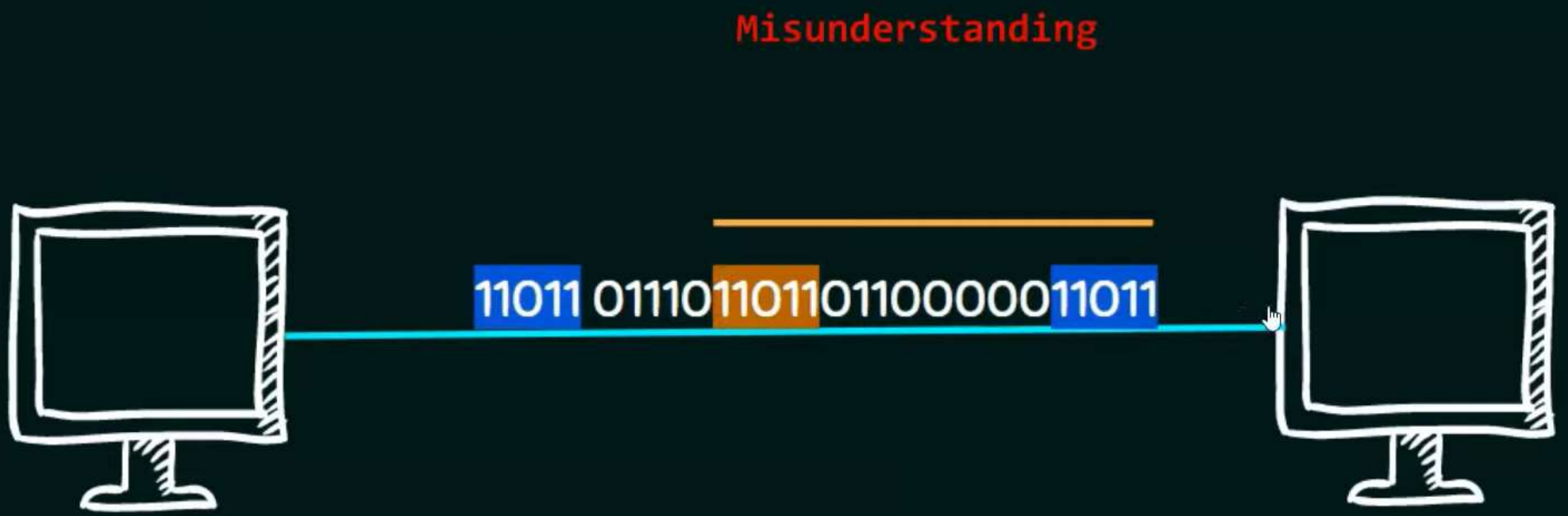

Let the start of frame and end of frame be 11011

# ANY PROBLEM HERE...



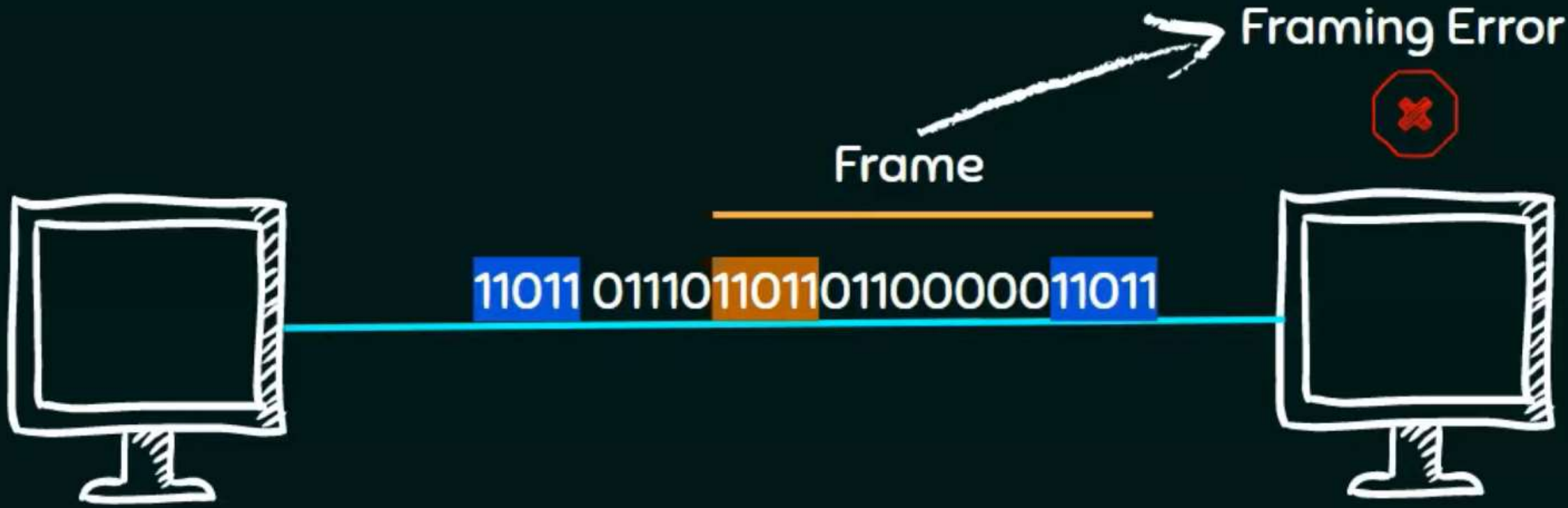

Let the start of frame and end of frame be 11011

# Framing error




Let the start of frame and end of frame be 11011

# Framing error




Let the start of frame and end of frame be 11011

# Framing

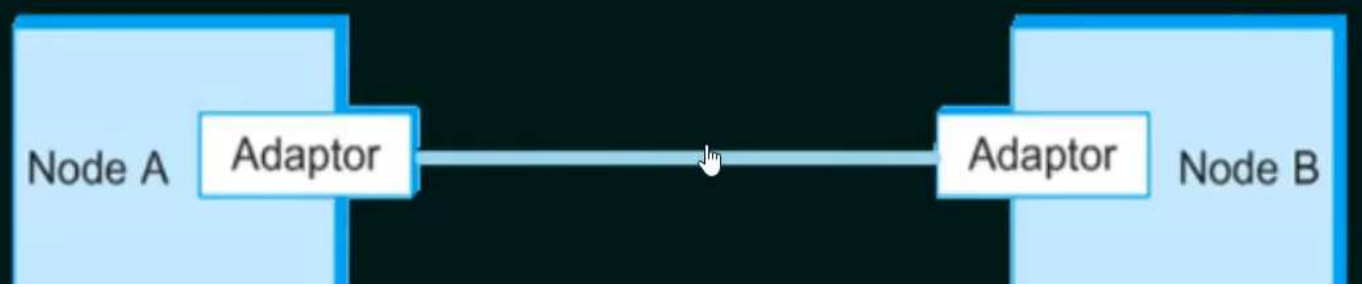
- ★ Framing in the data link layer separates a frame distinguishable from another frame.
- ★ Frame = Header + Network Layer PDU + Trailer.
- ★ In packet switched networks, the block of data called frames are exchanged between nodes, not bits streams.

# 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.

# 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.



# Types of framing

1. Fixed-size framing.
2. Variable-size 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.

# VARIOUS FRAMING APPROACHES

# 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.

# Byte oriented approach

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

# Byte oriented protocols

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

# Clock based framing

- ★ The third approach to framing is the clock based framing.
- ★ Example: SONET <-> Synchronous Optical Network.

# HDLC

- ★ The Synchronous Data Link Control (SDLC) protocol developed by IBM is an example of a bit-oriented protocol.
- ★ SDLC was later standardized by the ISO as the High-Level Data Link Control (HDLC) protocol.
- ★ Bit Oriented Protocol.

## HDLC – Frame format

# 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.

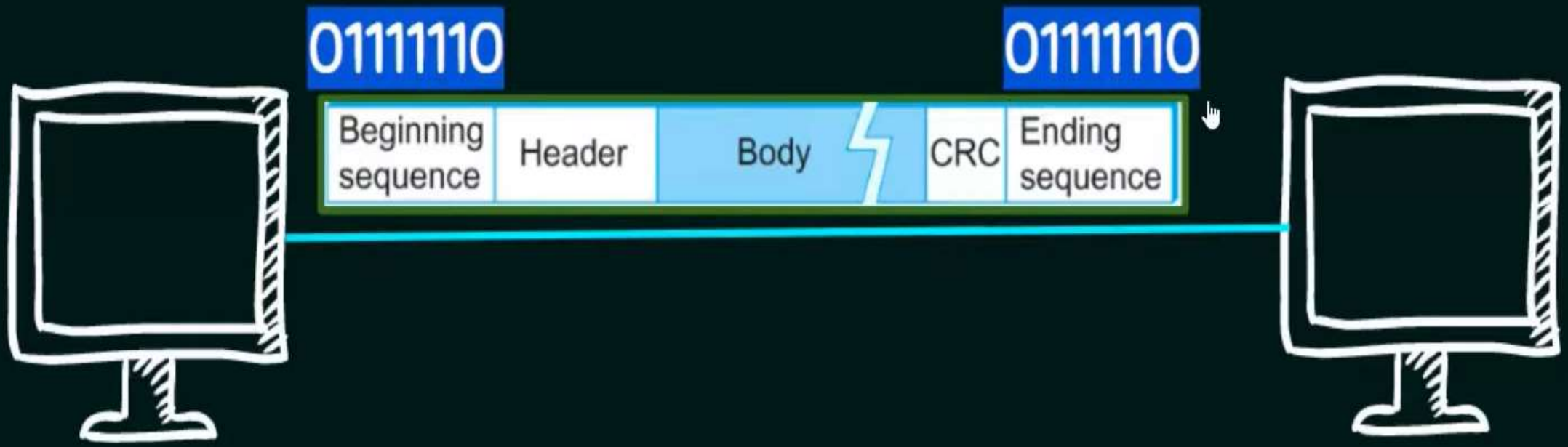
I-Frame: Information Frame.

S-Frame: Supervisory Frame.

U-Frame: Un-numbered Frame.

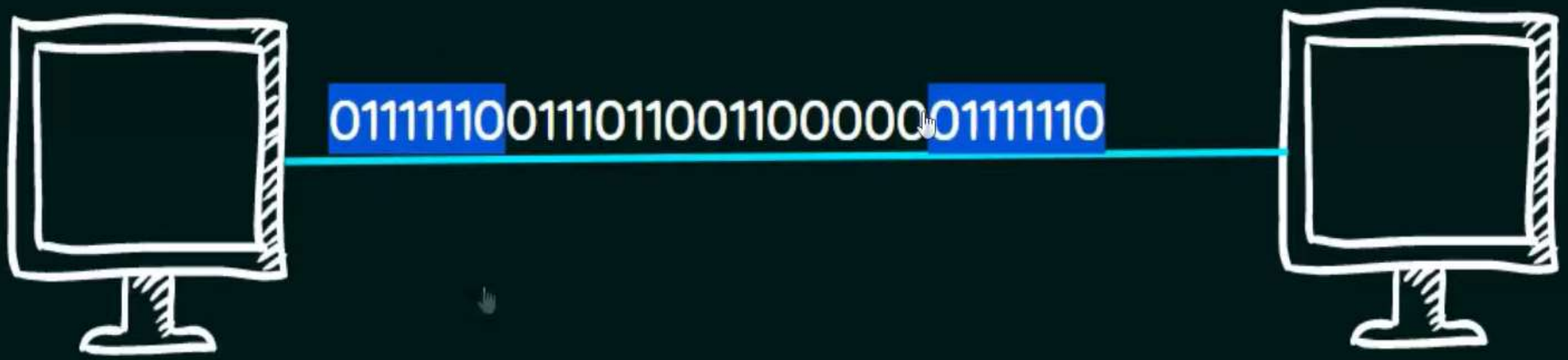
| | |
|---|---|
| I-Frame | 1st bit is 0 |
| S-Frame | 1st two bits is 10 |
| U-Frame | 1st two bits is 11 |

# FRAMING



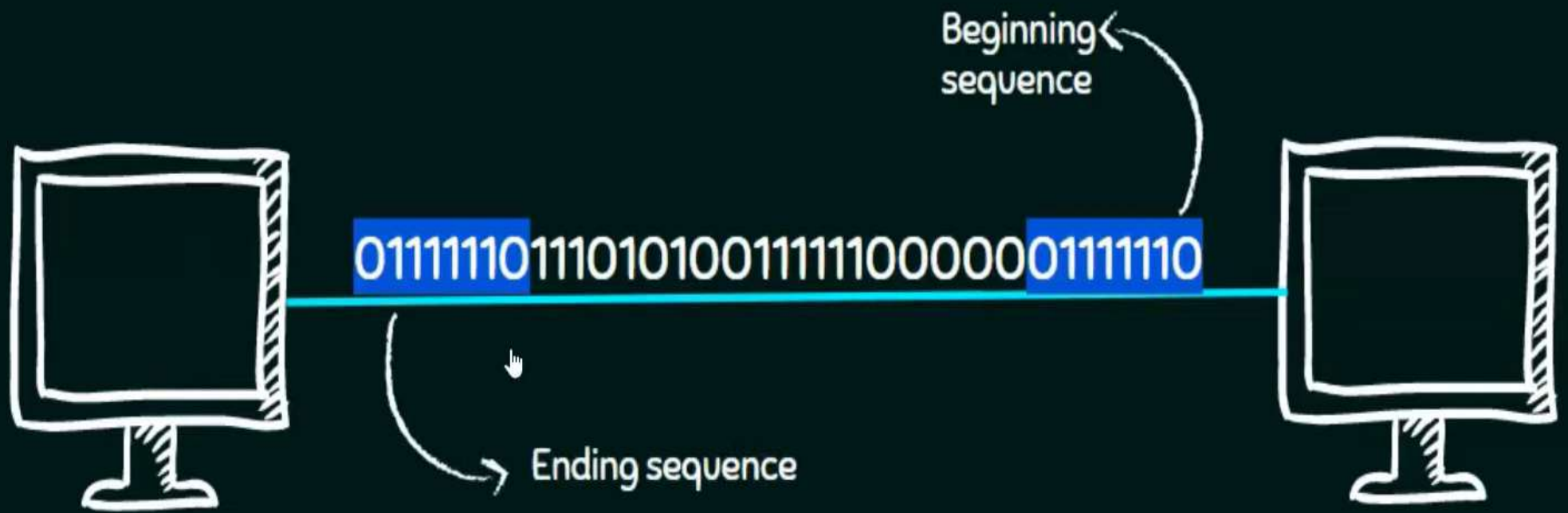

HDLC Protocol: Beginning and Ending Sequence is 01111110

# Framing



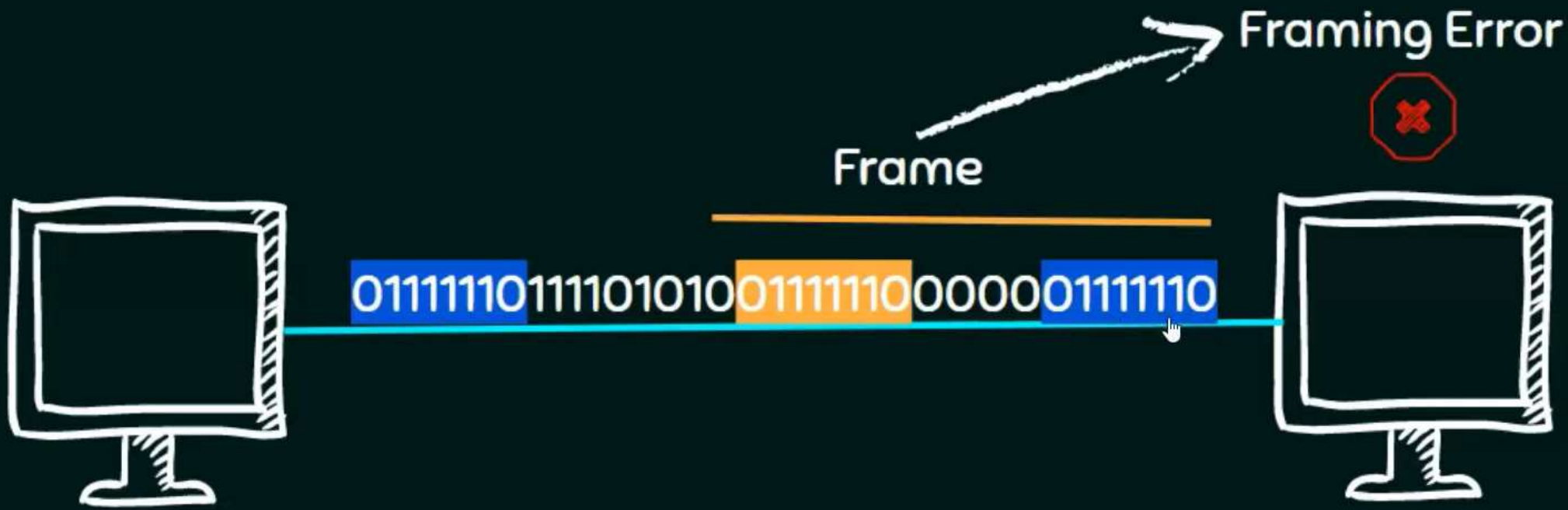

HDLC Protocol: Beginning and Ending Sequence is 01111110

# PROBLEM HERE...



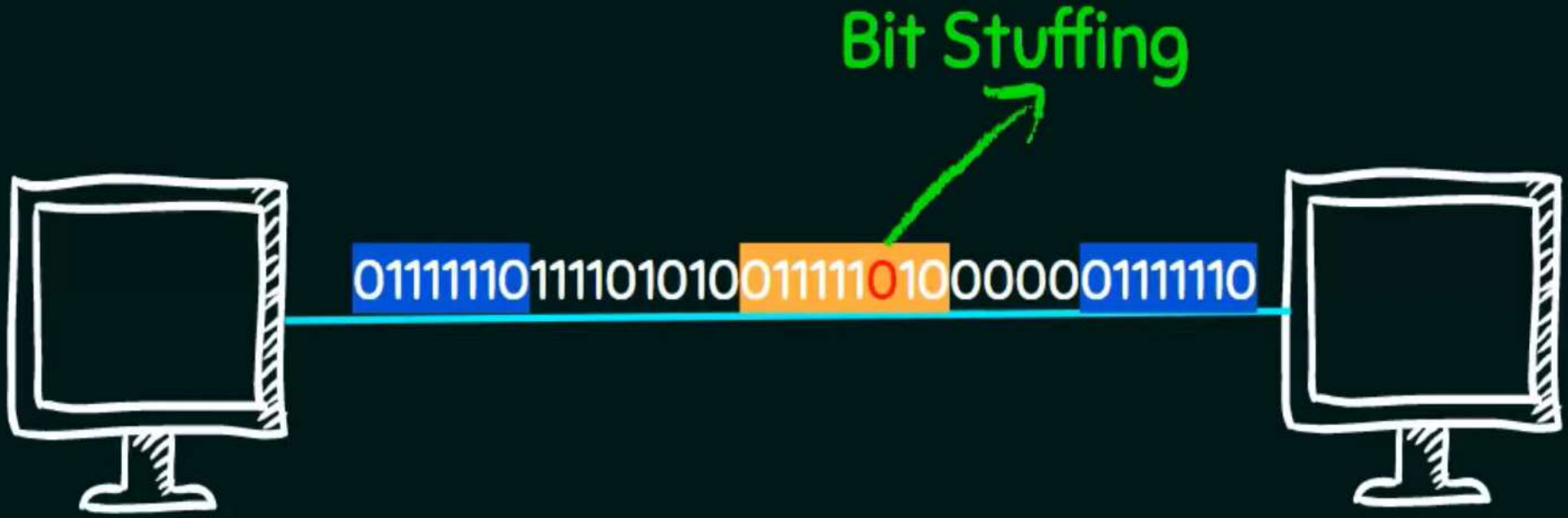

HDLC Protocol: Beginning and Ending Sequence is 01111110

# Problem




HDLC Protocol: Beginning and Ending Sequence is 01111110

# Bit stuffing




HDLC Protocol: Beginning and Ending Sequence is 01111110