COMPUTER NETWORK

CONCEPT OF DATA

- Data is information that conveys some meaning.
- In computing, data is information that has been translated into a form that is efficient for movement or processing.
- Relative to today's computers and transmission media, data is information converted into binary digital form.

CONCEPT OF DATA

This information may be in the form of text documents, images, audio clips, software programs, or other types of data.

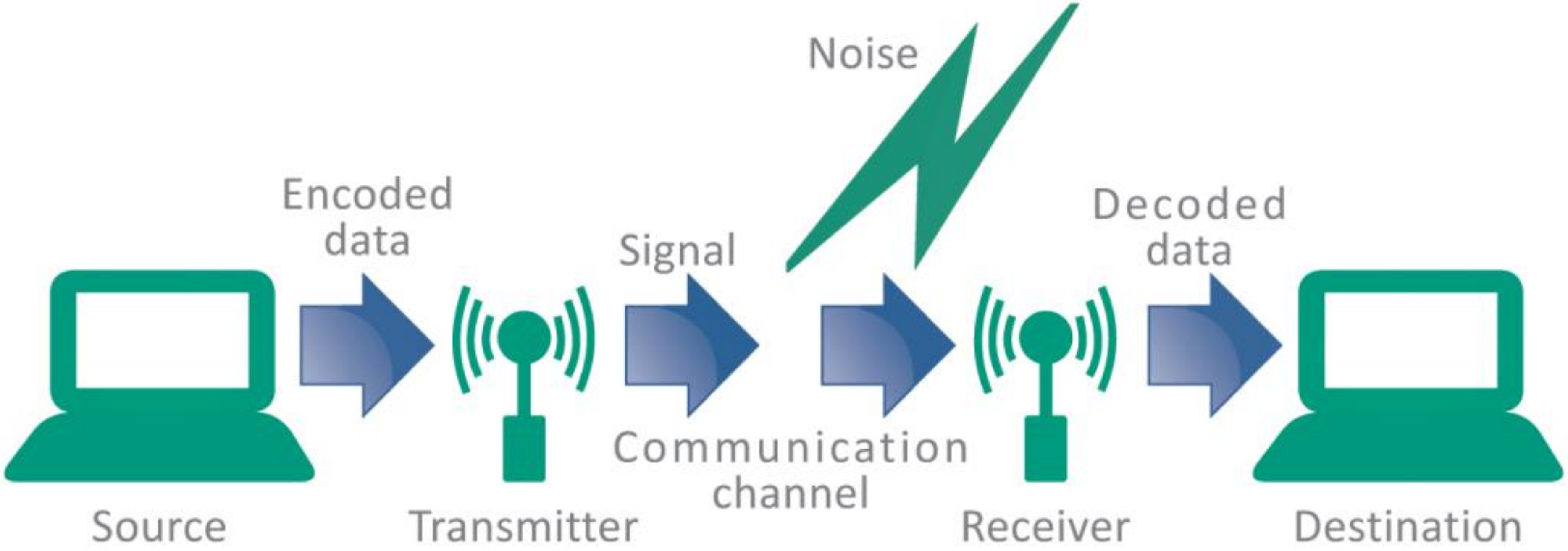
SIGNAL

A signal is an electromagnetic or electric current that carries data from one system or network to another.

Signals are passed between devices in order to send and receive information, which might be video, audio, or other data.

COMMUNICATION CHANNEL & CIRCUIT

- Communication channel refers to the medium used to transfer message from sender to receiver. E.g. of Channel: Copper Wires, Optical Wires, Optical Fibre, Wireless, etc.



COMMUNICATION CHANNEL & CIRCUIT

- A circuit is a specific path between two or more points along which signals can be carried. It is designed to permit data flow.

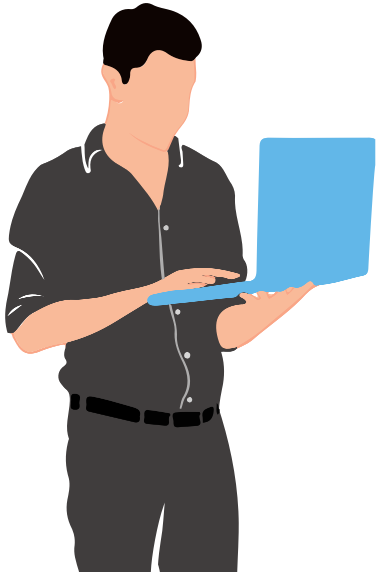
Simplex Circuit: Simplex is one-way transmission, such as that with radios and TVs.

Half Duplex Circuit: Half-duplex is two-way transmission, but you can transmit in only one direction at a time. E.g. Walkie-talkie

Full Duplex Circuit: With full-duplex transmission, you can transmit in both directions simultaneously. E.g. A telephone call where both parties can communicate at the same time.

Channel Speed & Bandwidth

Bandwidth is a measure of how much data can be sent and received at a time. The higher the bandwidth a network has, the more data it can send back and forth. The term bandwidth is not used to measure speed but rather to measure capacity.



Channel bandwidth is the **highest frequency in a channel minus the lowest frequency.**

Bandwidth

$$
\begin{aligned}
BW &= f_{max} - f_{min} \\
&= f_c + f_m - f_c + f_m
\end{aligned}
$$

$$\boxed{BW = 2f_m}$$

Bandwidth & Bandwidth

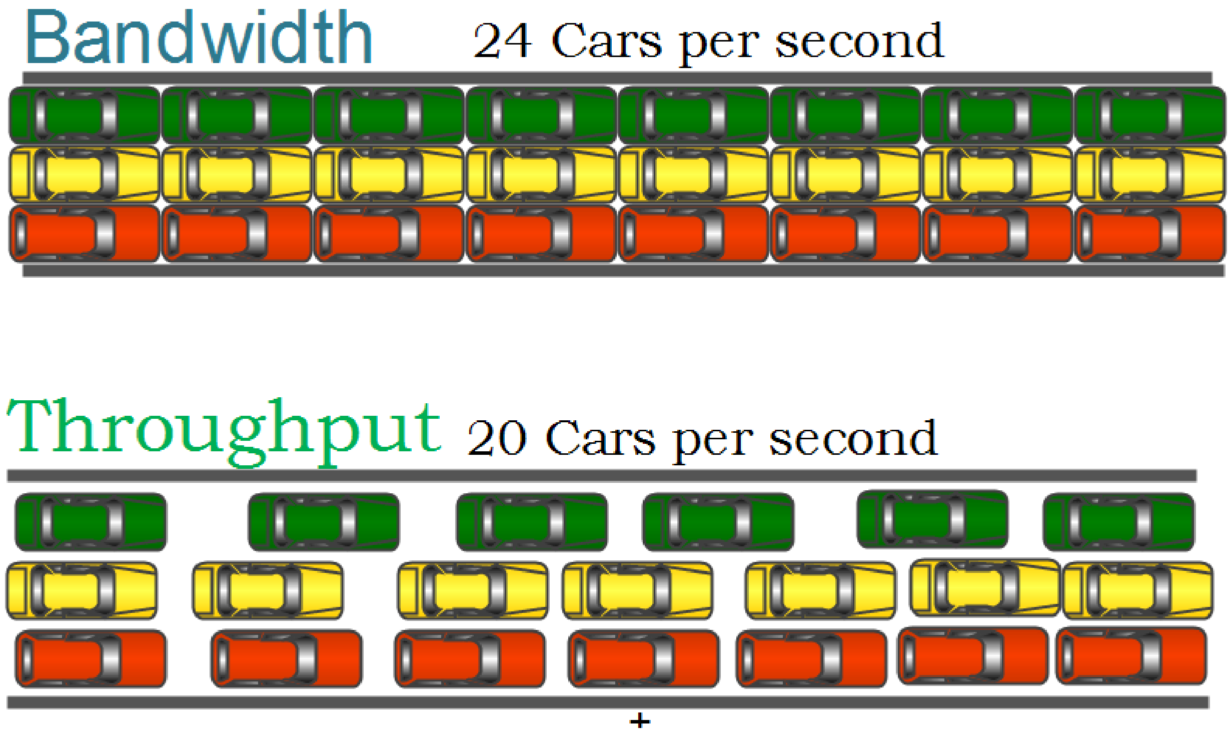
Bandwidth describes the information-carrying capacity of a medium, while throughput describes the actual use of that capacity.

To understand the basic difference between throughput and bandwidth, think about a highway. If 24 cars can go through on a highway in a second, then the bandwidth of that highway is 24 cars per second.

But, in practice, this never happens.

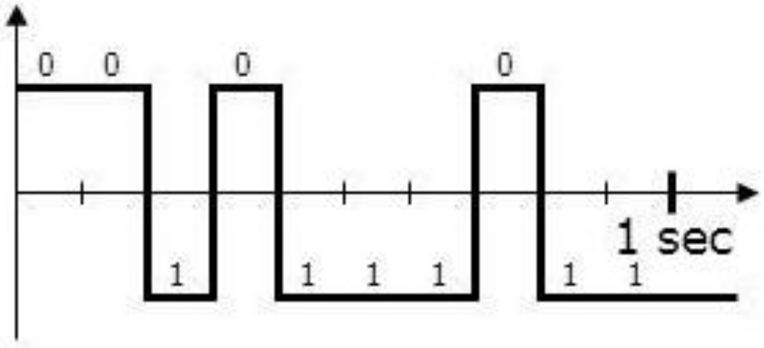
Bandwidth & Bandwidth

The actual number of cars that can go through depends on several conditions such as weather, road condition, and lights. If under given conditions only 20 cars can go through in a second, then the throughput of that highway is 20 cars per second.

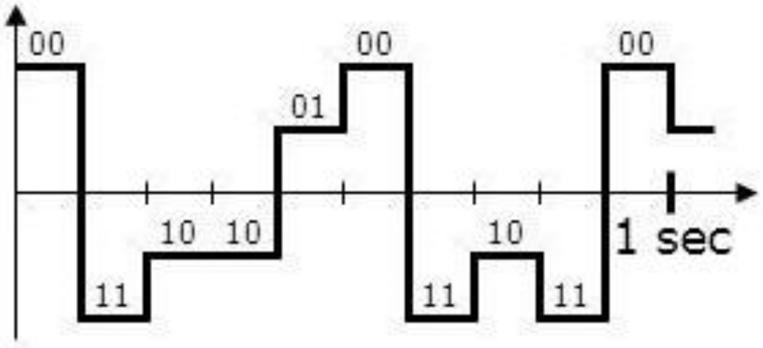


Bit rate & Baud rate

Baud rate is the number of changes in the signal (per second) that propagate through a transmission.
Bit rate is the numbers of binary bits transmitted per second.
Bit rate = Baud rate * Number of bit per baud
Baud Rate = Bit rate / the number of bit per baud



Baud = 10
Bit rate = 10 bps



Baud = 10
Bit rate = 20 bps

Maximum Data Rate of a Channel

Data rate refers to the speed of data transfer through a channel. It is generally computed in bits per second (bps). Higher data rates are expressed as Kbps ("Kilo" bits per second, i.e.1000 bps), Mbps, Gbps …

Two theoretical formulas were developed to calculate the data rate: one by Nyquist for a noiseless channel, another by Shannon for a noisy channel.

Noiseless Channel : Nyquist Bit Rate

For a noiseless channel, the Nyquist bit rate formula defines the theoretical maximum bit rate: Bit Rate = 2 * Bandwidth * log2(L)

In the above equation, bandwidth is the bandwidth of the channel, L is the number of signal levels used to represent data, and Bit Rate is the bit rate in bits per second.

Examples: *Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with two signal levels. What can be the maximum bit rate?*

Output: Bit Rate = 2 * 3000 * log2(2) = 6000bps

Noisy Channel : Shannon Capacity

In reality, we cannot have a noiseless channel; the channel is always noisy. Shannon capacity is used, to determine the theoretical highest data rate for a noisy channel: Capacity = bandwidth * log2(1 + SNR)

The SNR is often given in decibels. Assume that SNR(dB) is 36 and the channel bandwidth is 2 MHz. Find channel capacity.

Output: SNR(dB) = 10 * log10(SNR)

SNR = 10(SNR(dB)/10)

SNR = 103.6 = 3981

Hence, C = 2 * 106 * log2(3982) = 24 MHz

Propagation time

- The time required for a signal or wave to travel from one point of a transmission medium to another.
- The time taken to transmit a packet from the host to the transmission medium is called Transmission delay.

Propagation time

- For example, if bandwidth is 1 bps (every second 1 bit can be transmitted onto the transmission medium) and data size is 20 bits then what is the transmission delay? If in one second, 1 bit can be transmitted. To transmit 20 bits, 20 seconds would be required.
- Let B bps is the bandwidth and L bit is the size of the data then transmission delay is, Tt = L/B

Transmission time

- In telecommunication networks, the transmission time is the amount of time from the beginning until the end of a message transmission. In the case of a digital message, it is the time from the first bit until the last bit of a message has left the transmitting

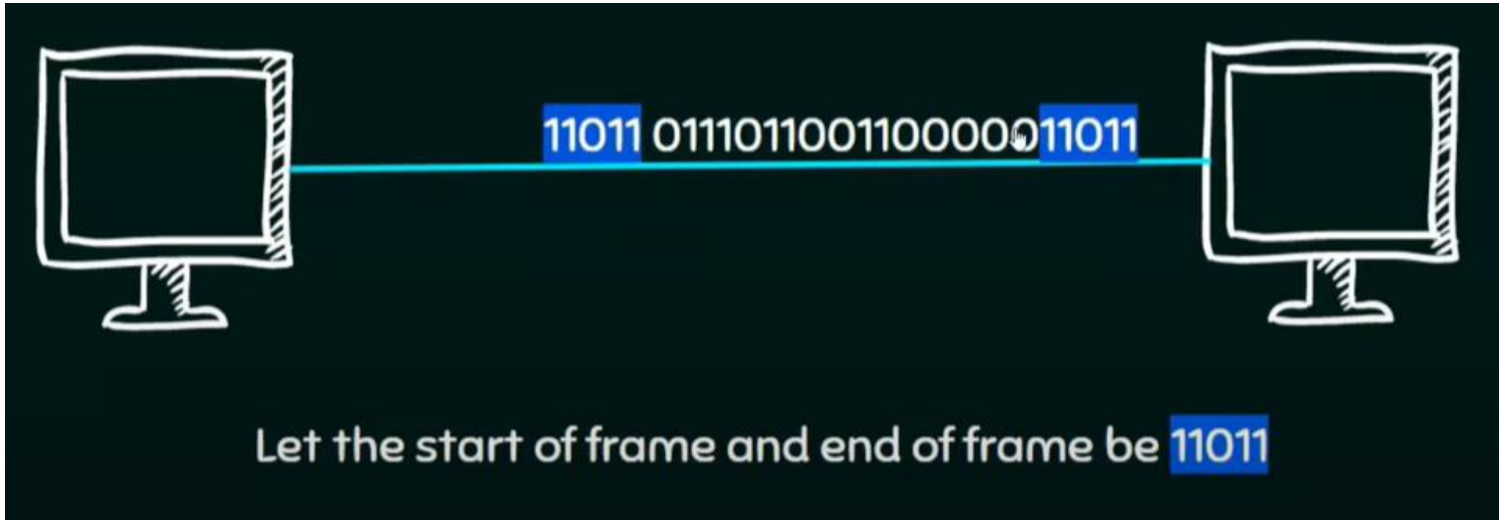
Farming

Just like packets, frames are small parts of a message in the network. Frames are the units of digital transmission, particularly in computer networks and telecommunications.

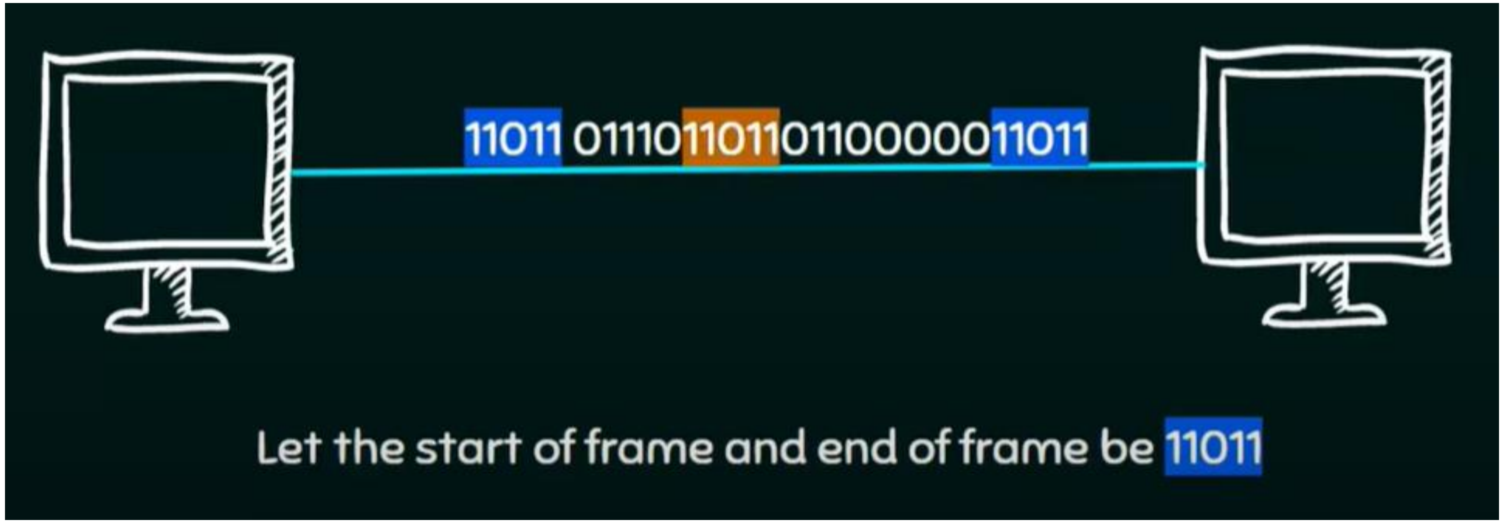
Framing is a point-to-point connection between two computers or devices consists of a wire in which data is transmitted as a stream of bits. However, these bits must be framed into discernible blocks of information.

Framing refers to the process of delimiting a frame (or packet), i.e. it is a method to indicate the start and ending of a packet or frame.

Framing

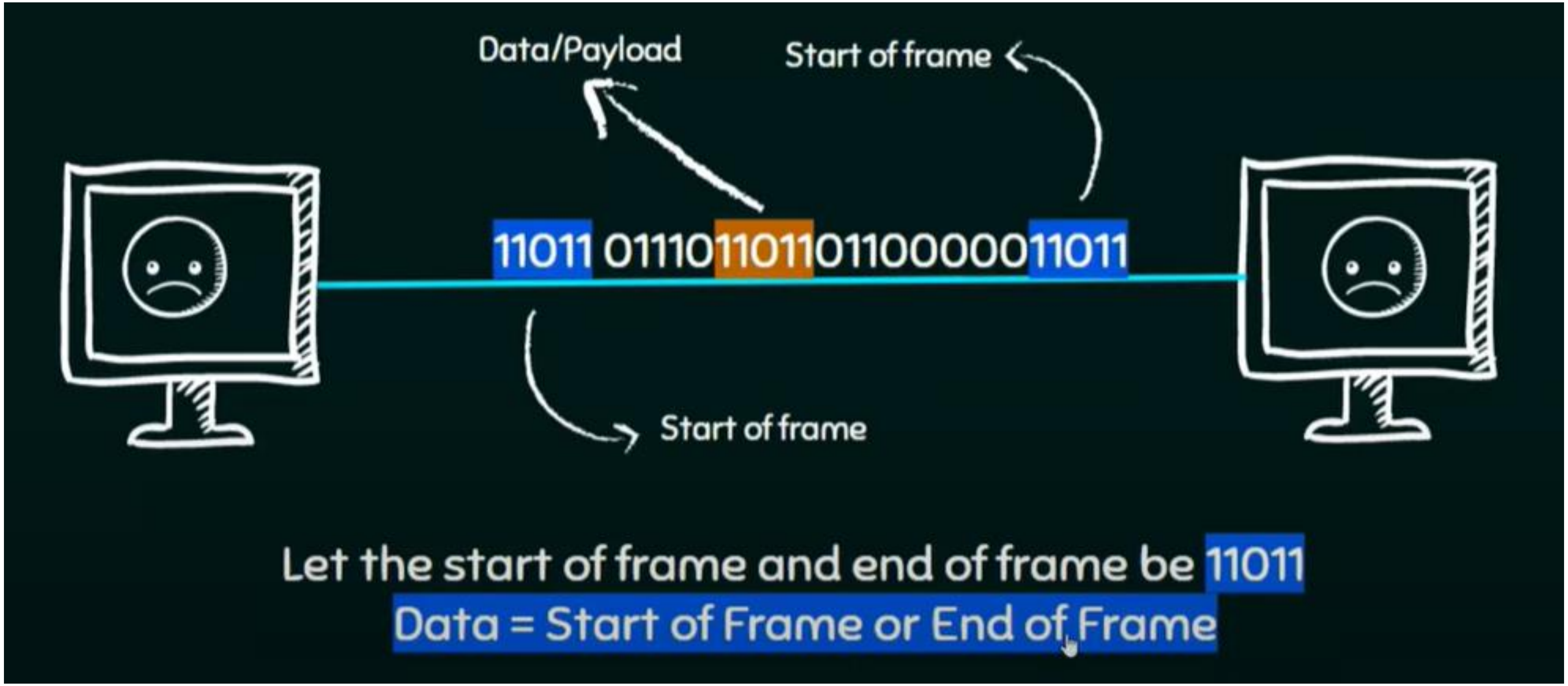


11011 0111011001100000 11011
Let the start of frame and end of frame be 11011



11011 01110 11011 0110000 11011
Let the start of frame and end of frame be 11011

Farming


Data/Payload
Start of frame
11011 01110110110110000011011
Start of frame
Let the start of frame and end of frame be 11011
Data = Start of Frame or End of Frame

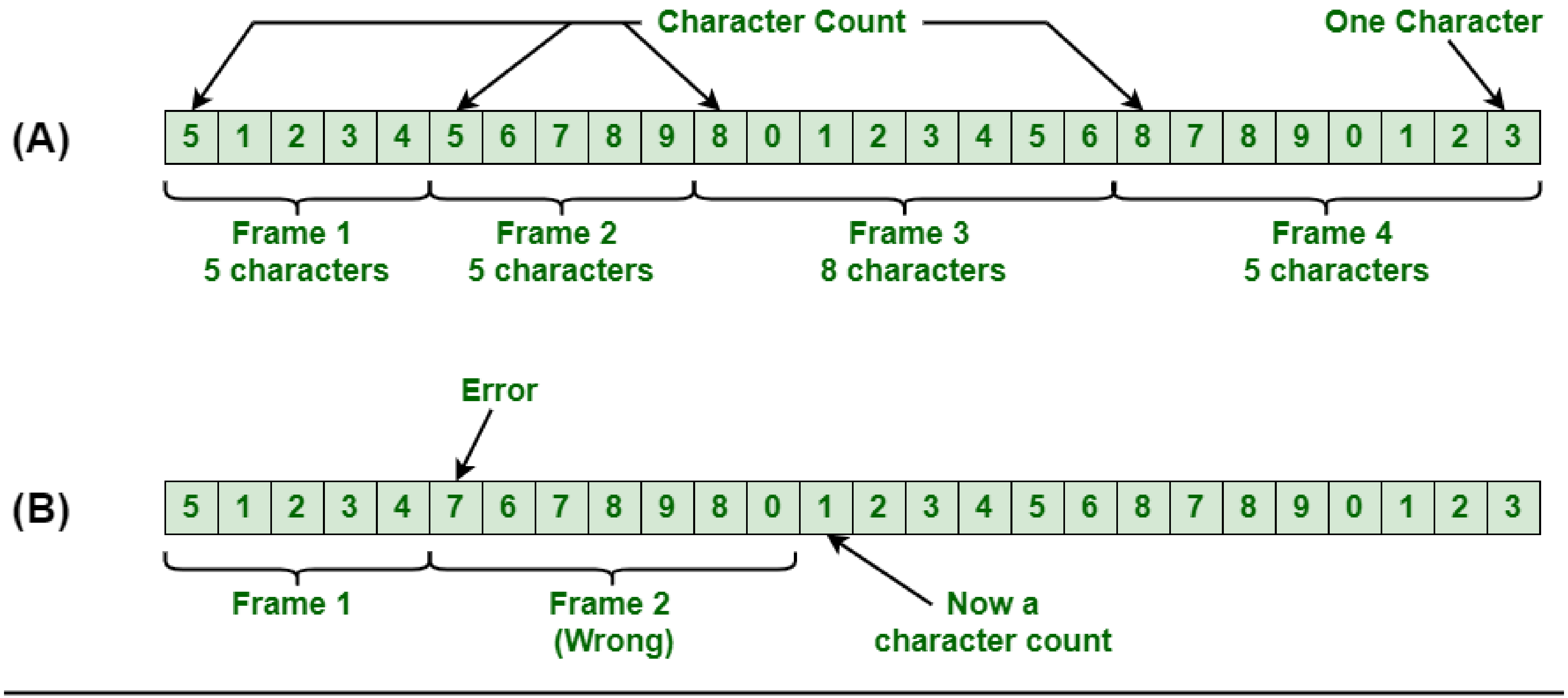
Framing Methods

Character Count

First framing method uses a field in the header to specify the number of characters in the frame. When the data link layer at the destination sees the character count, it knows how many characters follow and hence where the end of the frame is.

There is disadvantage also of using this method i.e., if anyhow character count is disturbed or distorted by an error occurring during transmission, then destination or receiver might lose synchronization. The destination or receiver might also be not able to locate or identify beginning of next frame.

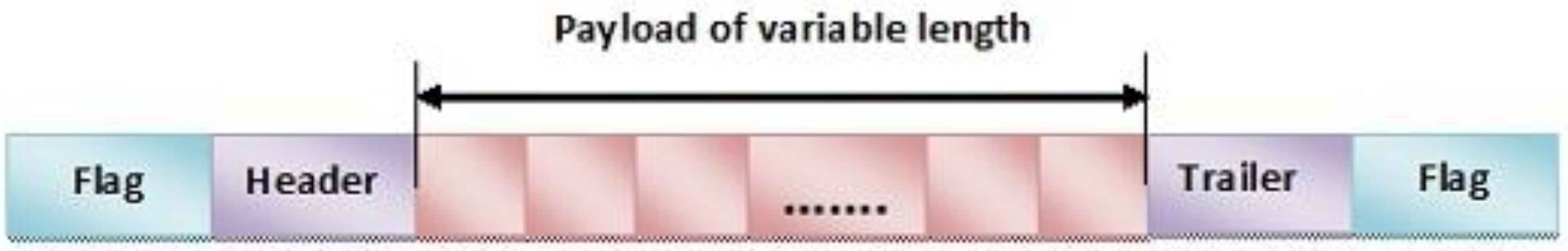
Framing Methods



A Character Stream

(A) Without Errors
(B) With one Error

Framing Methods



Frame Header – It contains the source and the destination addresses of the frame.

Payload field – It contains the message to be delivered.

Trailer – It contains the error detection and error correction bits.

Flags – 1- byte (8-bits) flag at the beginning and at end of the frame. It is a protocol – dependent special character, signaling the start and end of the frame.

Framing Methods

Flag Byte Stuffing

If the pattern of the flag byte is present in the message byte, there should be a strategy so that the receiver does not consider the pattern as the end of the frame. In character – oriented protocol, the mechanism adopted is byte stuffing.

In byte stuffing, a special byte called the **escape character (ESC)** is stuffed before every byte in the message with the same pattern as the flag byte. If the ESC sequence is found in the message byte, then another ESC byte is stuffed before it.

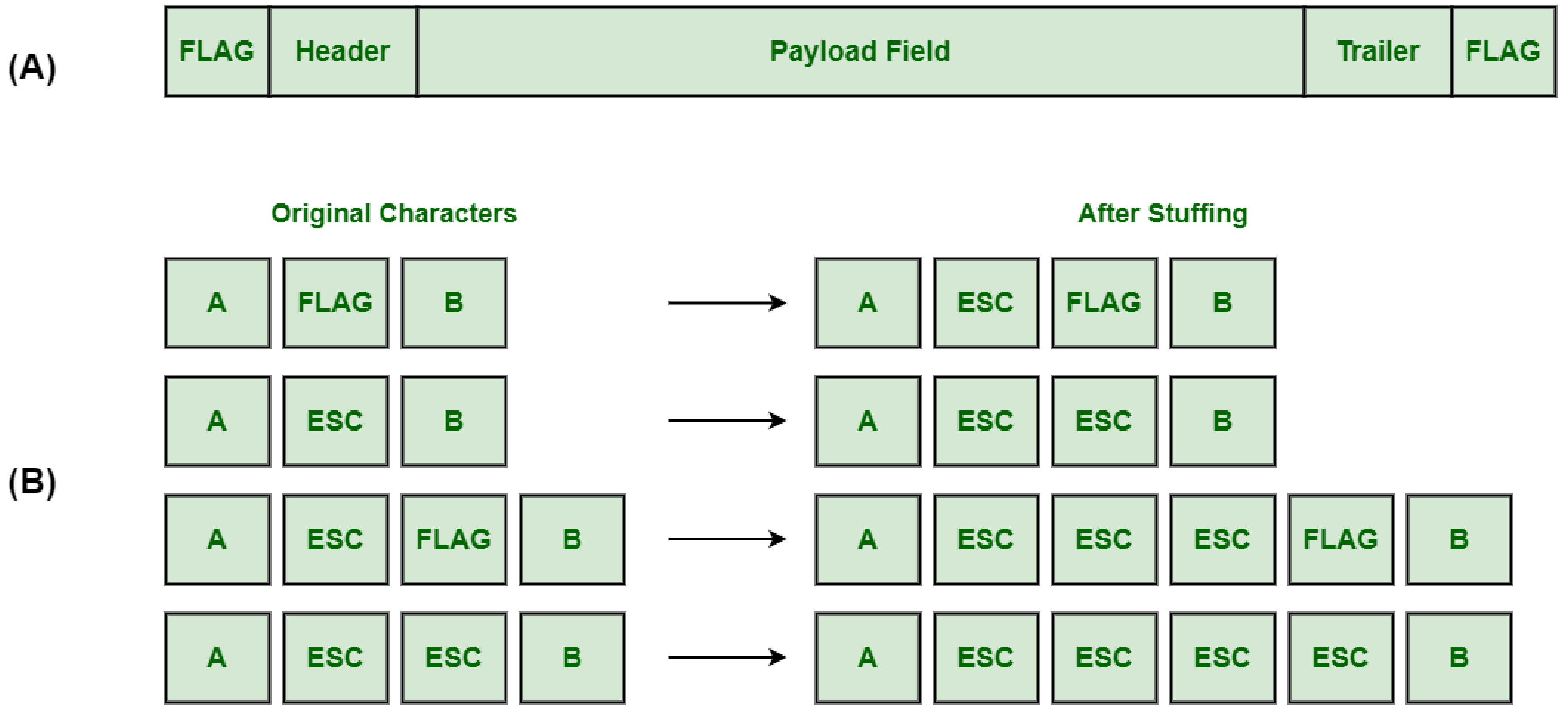
Framing Methods

Flag Byte Stuffing

In Data Link layer, the stream of bits from physical layer are divided into data frames. The data frames can be of fixed length or variable length.

In variable – length framing, the size of each frame to be transmitted may be different. So, a pattern of bits is used as a delimiter to mark the end of one frame and the beginning of the next frame

Flag Byte Stuffing

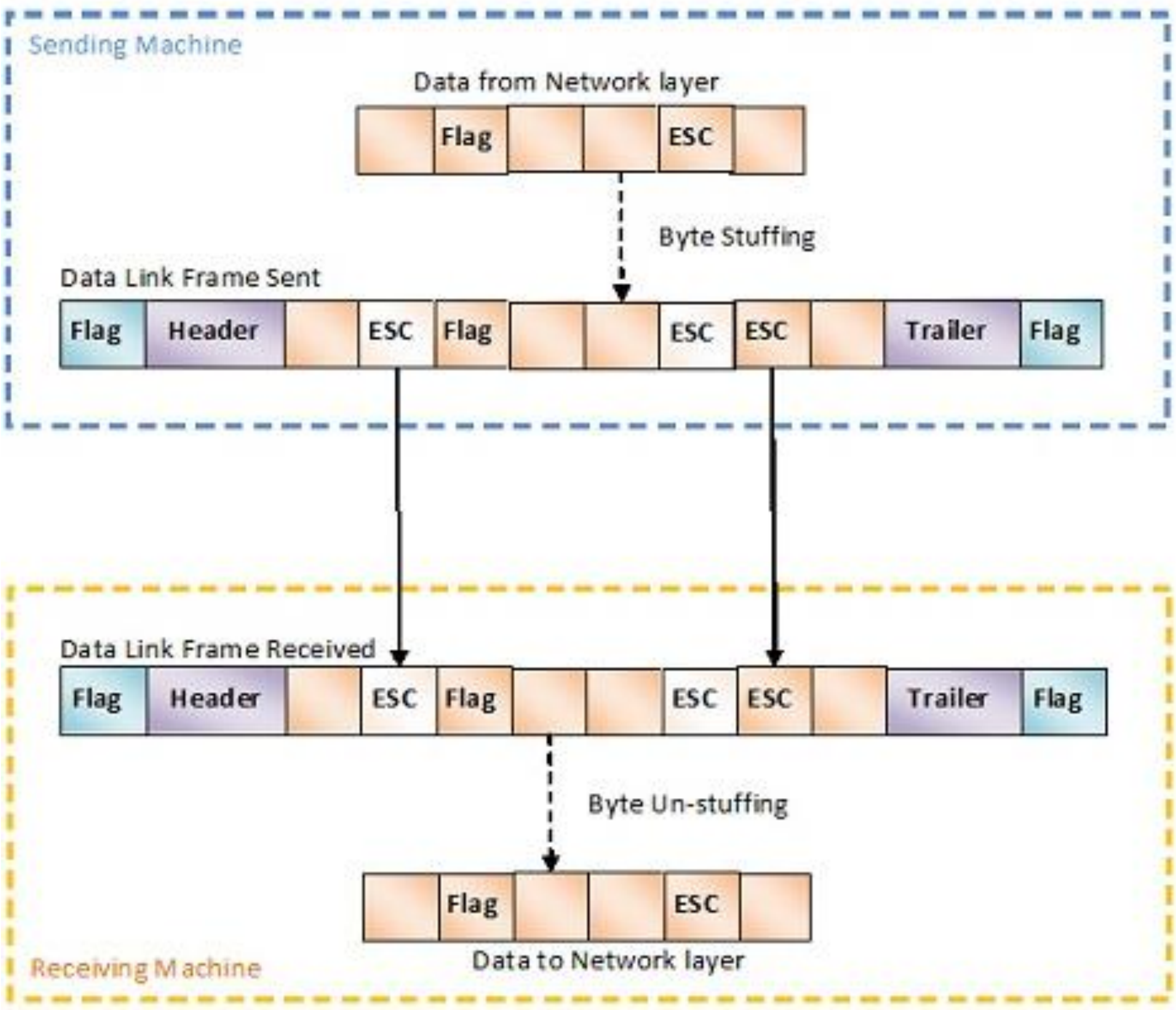


A Character Stuffing

(A) A frame delimited by flag bytes

(B) Four examples of byte sequences before and after byte stuffing

Flag Byte Stuffing



Framing Methods

Bit Stuffing

Bit stuffing is the insertion of non-information bits into data. Note that stuffed bits should not be confused with overhead bits.

Overhead bits are non-data bits that are necessary for transmission (usually as part of headers, checksums etc.).

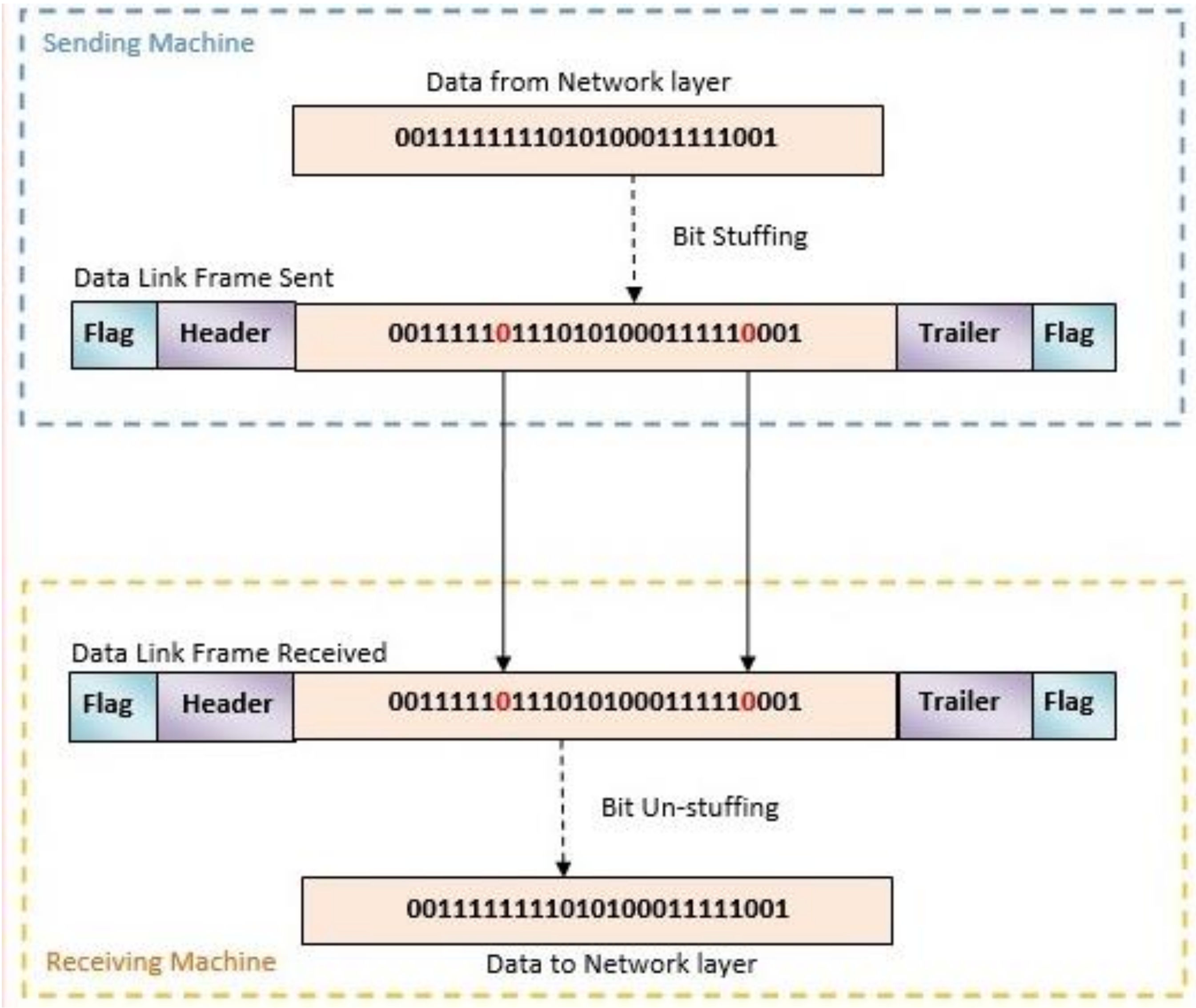
Framing Methods

Bit Stuffing

In a data link frame, the delimiting flag sequence generally contains six or more consecutive 1s. In order to differentiate the message from the flag in case of the same sequence, a single bit is stuffed in the message. Whenever a 0 bit is followed by five consecutive 1bits in the message, an extra 0 bit is stuffed at the end of the five 1s.

When the receiver receives the message, it removes the stuffed 0s after each sequence of five 1s.

Bit Stuffing



Bit Stuffing

Example of bit stuffing:

110101111101011111101011111110 (without bit stuffing)
110101111100101111101010111110110 (with bit stuffing)

After 5 consecutive 1-bits, a 0-bit is stuffed. Stuffed bits are marked bold.