Bit and Byte Stuffing

Synchronous versus Asynchronous Transmissions

- There exists a hierarchy of synchronization tasks:
  - *Bit level* : recognizing the start and end of each bit
  - *Character or byte level* : recognizing the start and end of each character (or small unit of data)
  - *Block or message level* : recognize the start and end of each large unit of data (in networks this is a **frame**).

Synchronous versus Asynchronous Transmissions [Halsall]

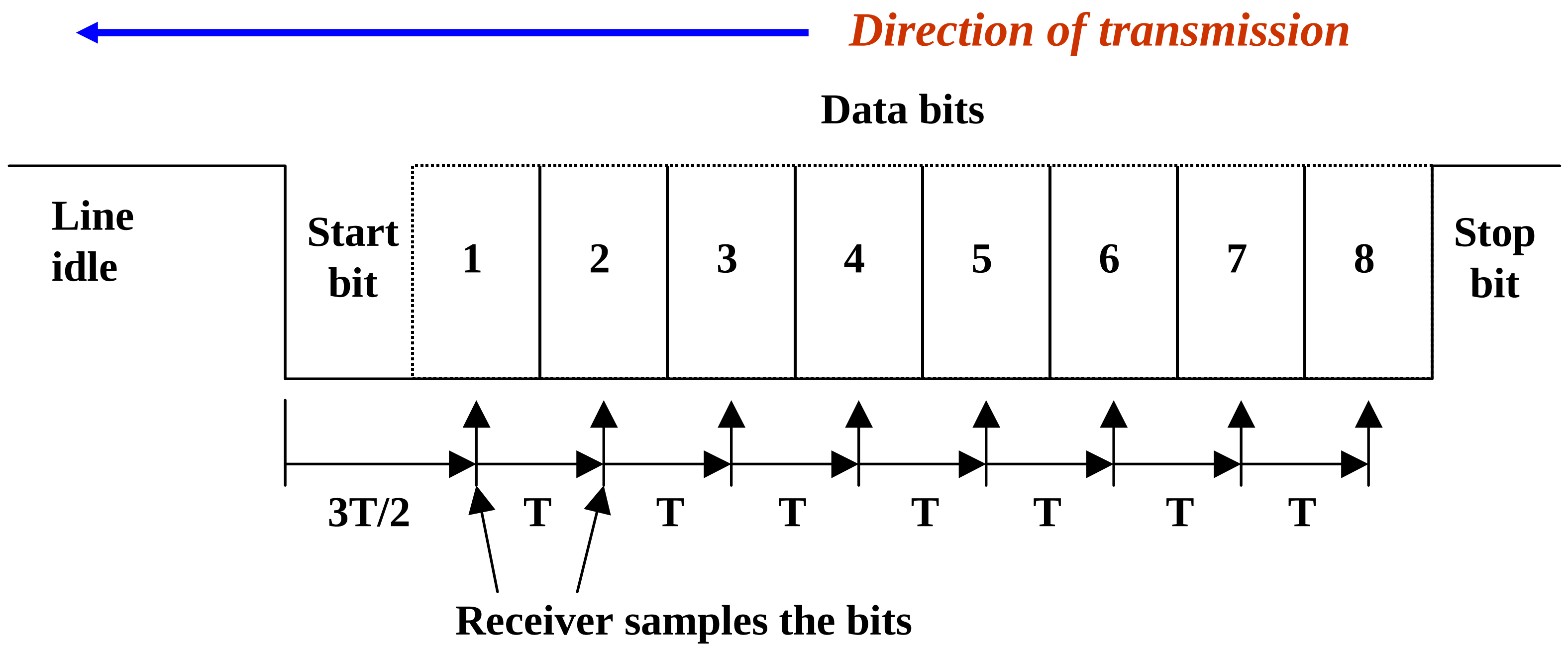
*A fundamental requirement of digital data communications is that the **receiver** knows the starting time and the duration of each bit.*

Asynchronous transmission :: each character (or byte) is treated independently for clock (bit) and character (byte) synchronization purposes and the receiver resynchronizes at the start of each character received.

Synchronous transmission :: the complete **frame** is transmitted as a contiguous string of bits and the receiver endeavors to keep in synchronism with the incoming bit stream for the duration of the frame.

Framing Synchronization in Asynchronous Transmission

Transmitted at random intervals (e.g., keyboard)



 Leon-Garcia & Widjaja: *Communication Networks* Figure 3.68

Synchronous Transmissions

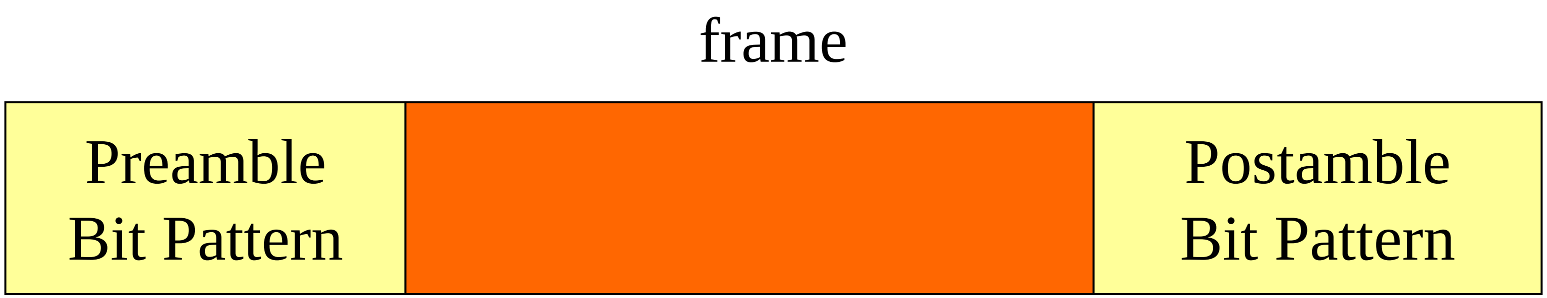
- More efficient, i.e., less overhead
- Blocks of characters transmitted without start and stop codes
- The transmitted stream is suitably encoded so the receiver can stay *in "synch"* by:
  - Using a separate clock line
  - Embedding clocking information into data (e.g. biphase coding).

Methods to Identify Frames

[Tanenbaum]

1. Byte counts
2. Starting/ending bytes [byte stuffing]
3. Starting/ending flags [bit stuffing]
4. Using physical layer coding violations (i.e., invalid physical codes)

The contents of each frame are *encapsulated* between a pair of reserved characters or bytes for frame synchronization.



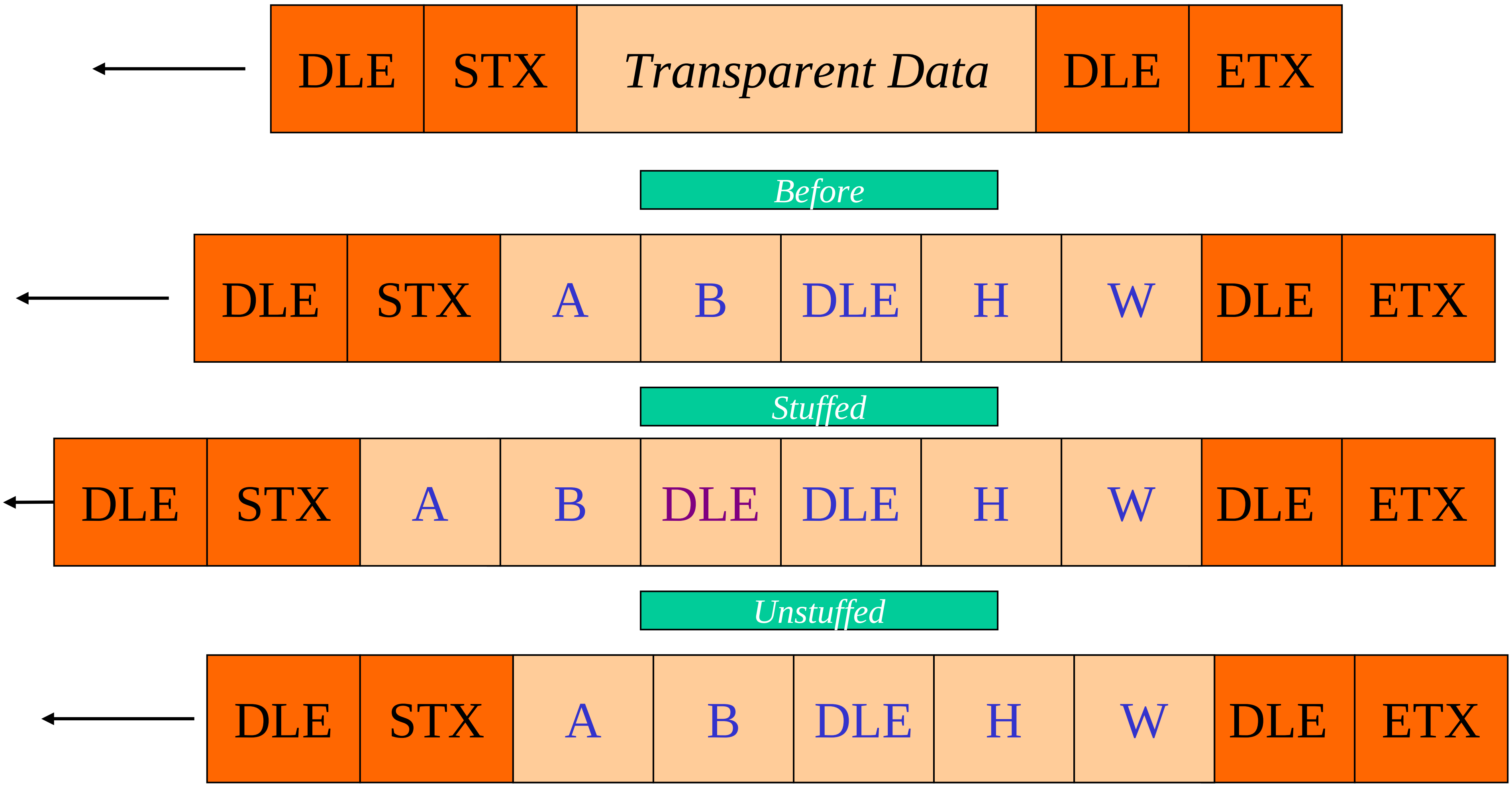
Byte Stuffing
[HDLC Example]

- *Also referred to as <u>character stuffing.</u>*
- ASCII characters are used as framing delimiters (e.g. DLE STX and DLE ETX)
- The problem occurs when these character patterns occur within the "transparent" data.

Solution: sender stuffs an **extra DLE** into the data stream just before each occurrence of an "accidental" DLE in the data stream.

The data link layer on the receiving end unstuffs the DLE before giving the data to the network layer.

HDLC Byte Stuffing



Bit Stuffing

- Each frame begins and ends with a special bit pattern called a flag byte [01111110]. {Note this is **7E in hex}**
- Whenever sender data link layer encounters *five consecutive ones* in the data stream, it automatically stuffs a 0 bit into the outgoing stream.
- When the receiver sees *five consecutive incoming ones followed by a 0 bit*, it automatically destuffs the 0 bit before sending the data to the network layer.

Bit Stuffing

Input Stream

0110111111100111110111111111100000

Stuffed Stream

01101111101100111110011111011111000000

Stuffed bits

Unstuffed Stream

0110111111100111110111111111100000

PPP (Point-to-Point Protocol) Frame Format

Flag 01111110	Address 1111111	Control 00000011	Protocol	Information	CRC	flag 01111110

All stations are to accept the frame

Unnumbered frame

Specifies what kind of packet is contained in the payload, e.g., LCP, NCP, IP, OSI CLNP, IPX

 Leon-Garcia & Widjaja: *Communication Networks* Figure 5.40

PPP Byte Stuffing

Flag	Address	Control	Protocol	Information	CRC	Flag
01111110	1111111	00000011				01111110

Input

7E		7D	33		7E	42		7E

Stuffed Stream

7E		7D	5D	33		7D	5E	42		7E

Unstuffed Stream

7E		7D	33		7E	42		7E