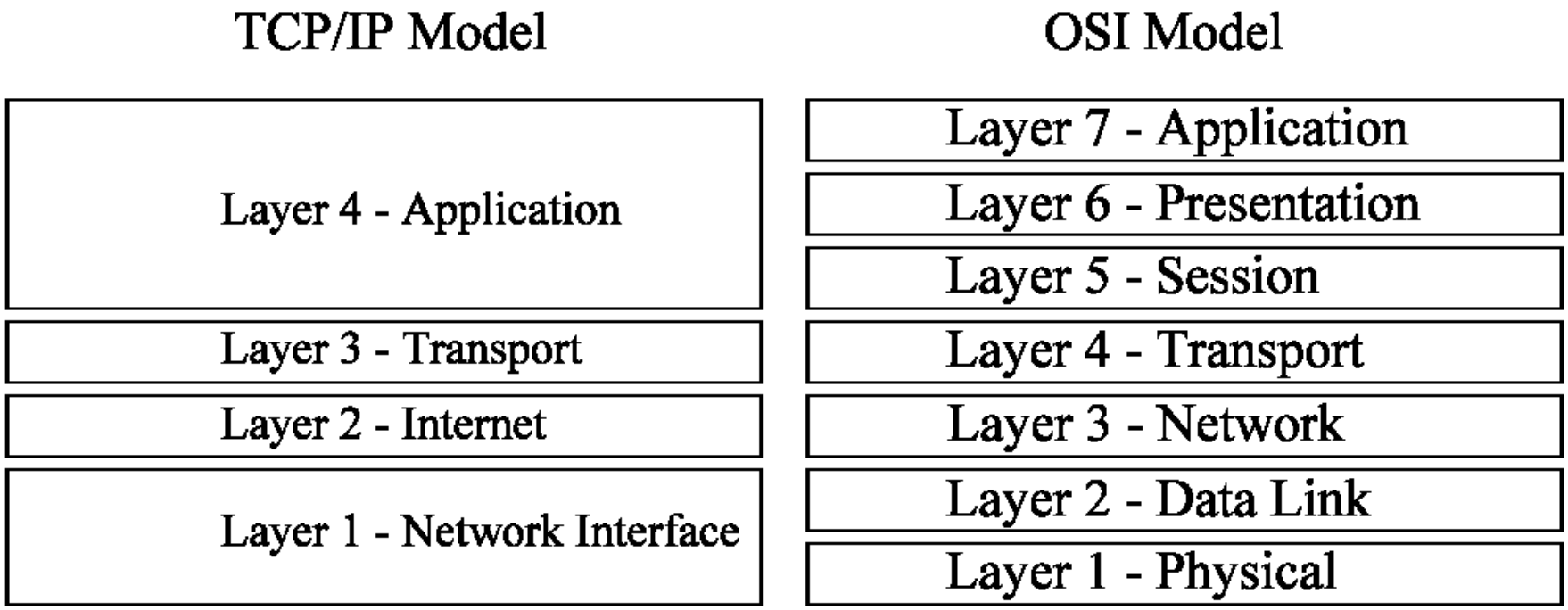
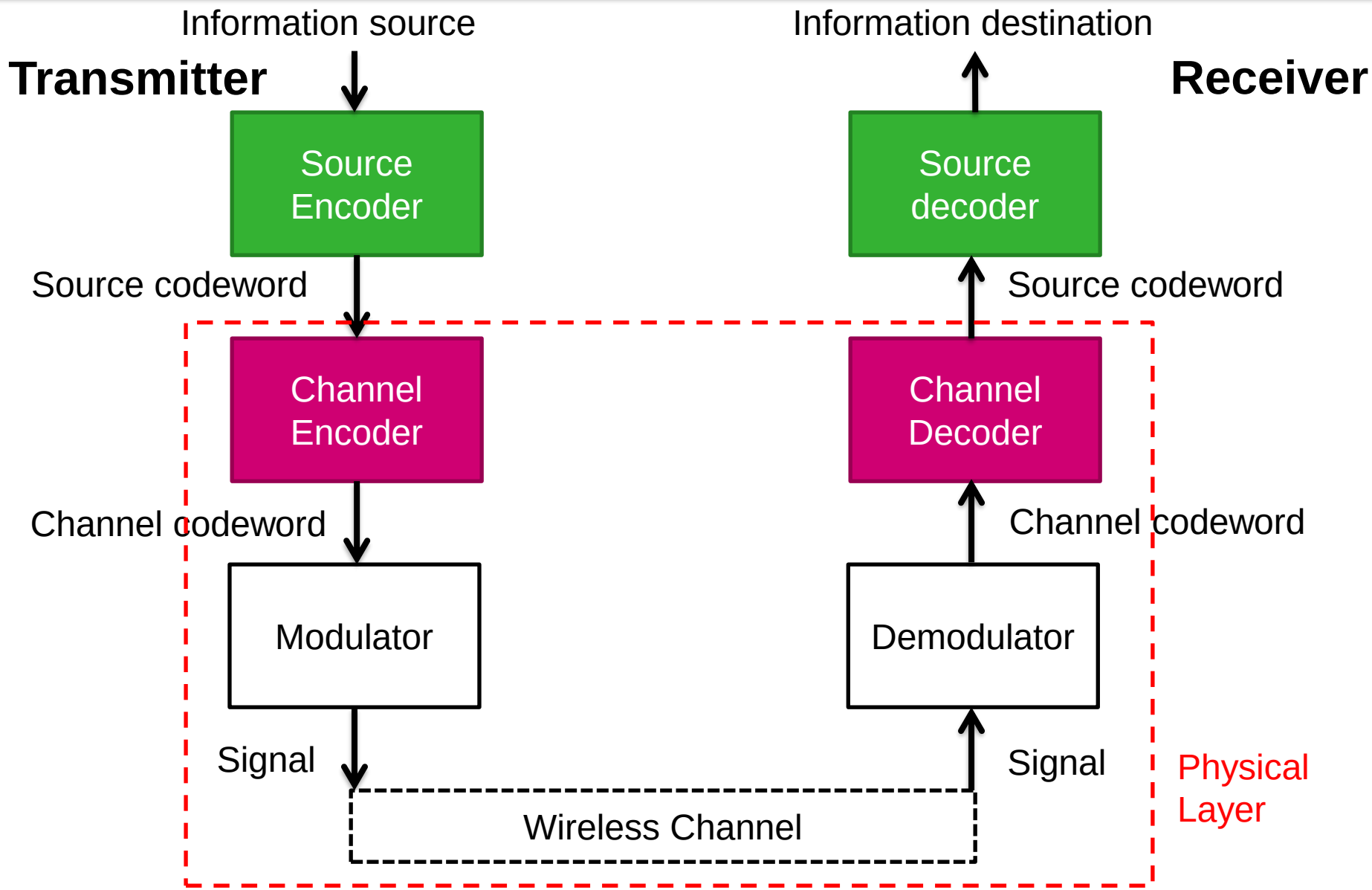
Physical Layer

Protocol stack layers



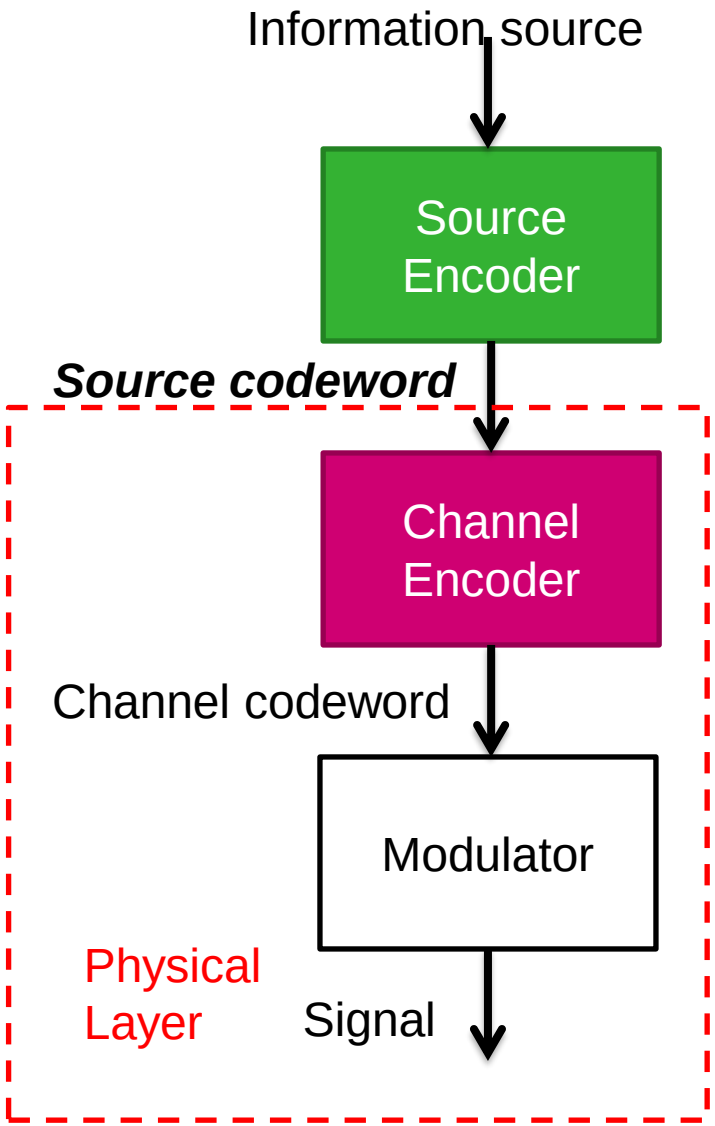
Source: www.tis97.co.uk

Physical Layer in Wireless Networks



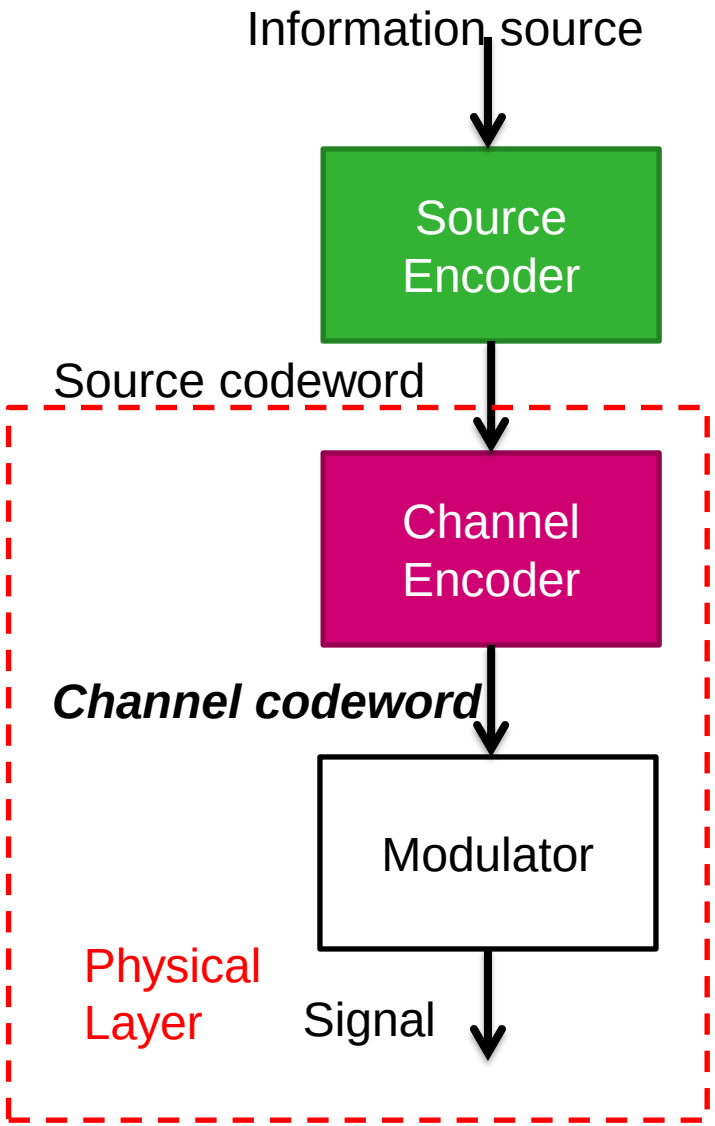
Source Encoder

- Encodes the information into a ***source codeword***
- Example:
  - Pulse code modulation (PCM) to encode analog voice signal as digital codeword
- Also can do compression
  - Based on information statistics, use fewer number of bits



Channel Encoder

- Encodes the source codeword as a channel ***codeword***
- Goal: Allow receiver to
  - Identify bit errors
  - Correct (limited number) of bit errors



Channel Encoding

Examples for error control encoding:

- Add error detection codes to the data
  - Parity bits
  - Cyclic Redunancy Check (CRC)
- Block coding
- Interleaving

Interleaving

- Problem: electromagnetic spikes can cause burst errors

  -> Many errors in one code word

  -> Exceeds error-correcting capabilities of the used code

- Example:
  - Let's assume an error control coding that can correct one error in a code word
  - Codewords: "Hello" "World"

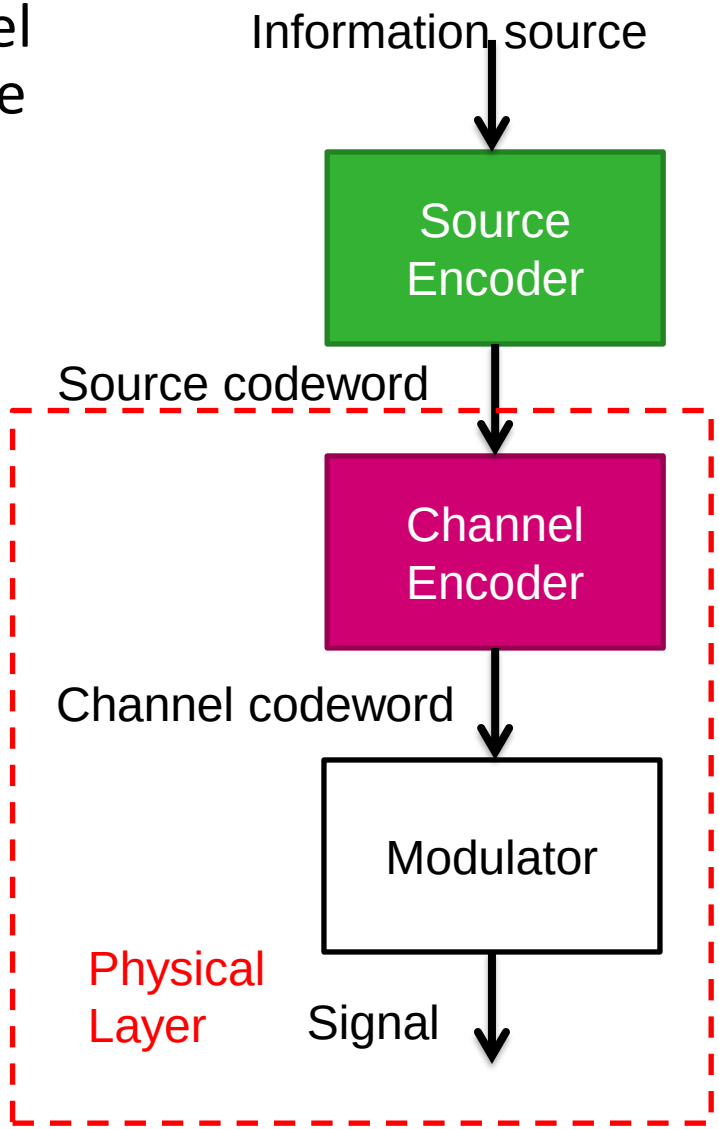
    Burst errors (two errors in one word)
- Possible solution: *Interleaving*
  - Shuffle symbols to distribute error over several words

    "HWeol" "rllod"
  - Receiver will unshuffle the words and the correct the error in the codwords

Modulator

- The carrier signal of the wireless channel is modulated according to the bits of the channel codeword

- What does that mean???



Modulation

- Radio wave as a sine function:

$$signal(t) = A \cdot \sin(2\pi \cdot t \cdot f + \varphi)$$

A: amplitude, f: frequency, φ: phase, t: time

- Modulation = manipulate these parameters as a function of time to transmit the data
- Often, a **carrier wave** is used = a wave of a certain frequency whose parameters are manipulated

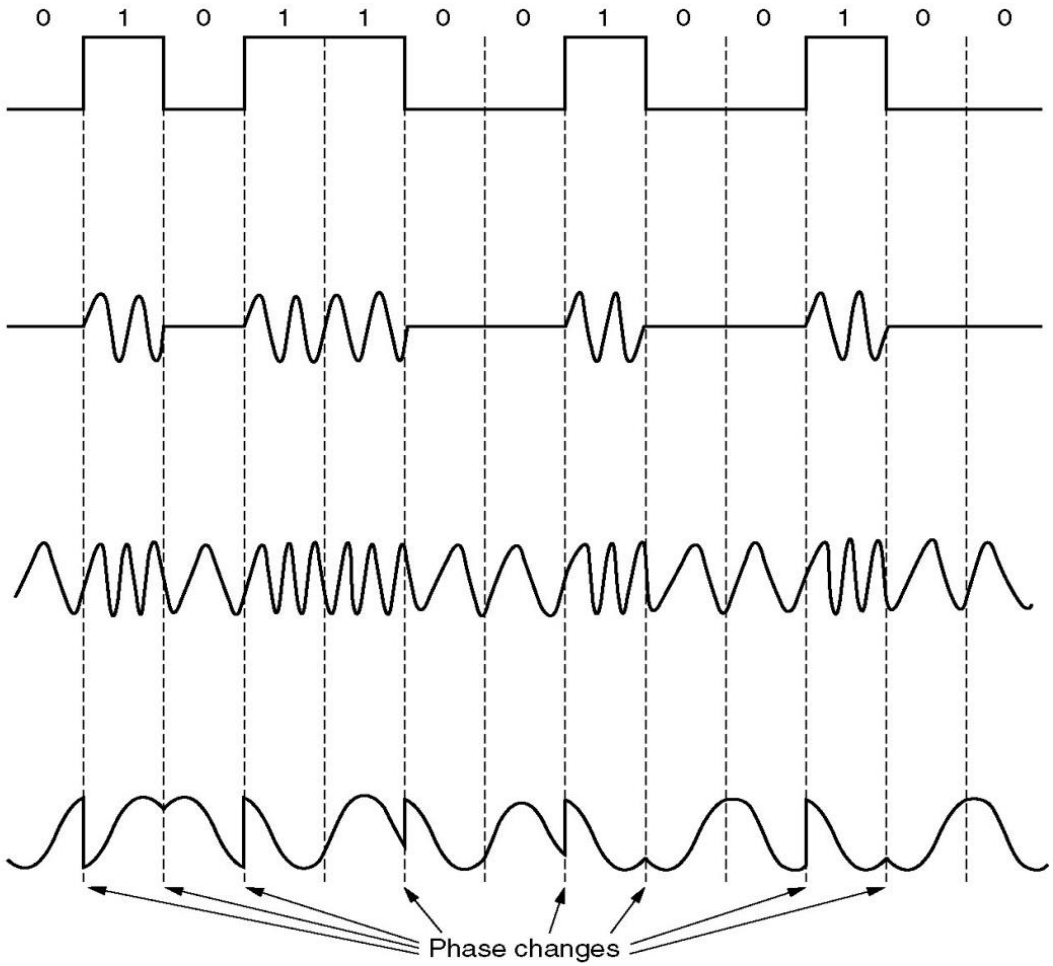
Modulation (Keying) examples

Channel codeword (a)

Amplitude Shift Keying (ASK) (b)

Frequency Shift Keying (FSK) (c)

Phase Shift Keying (PSK) (d)



Demodulation

- On the receiver side, the signal is demodulated

- Challenges:
  - Bit synchronization: when does the bit start?
  - Frame synchronization: when does a packet/frame start?
  - Sender and receiver might not be exactly listening to the same frequency (because of drift, aging, etc. in electronics)
  - Noise, interferences of channel
  - …
- Will not be discussed here. Those problems are addressed by a combination of hardware and signal processing algorithms.