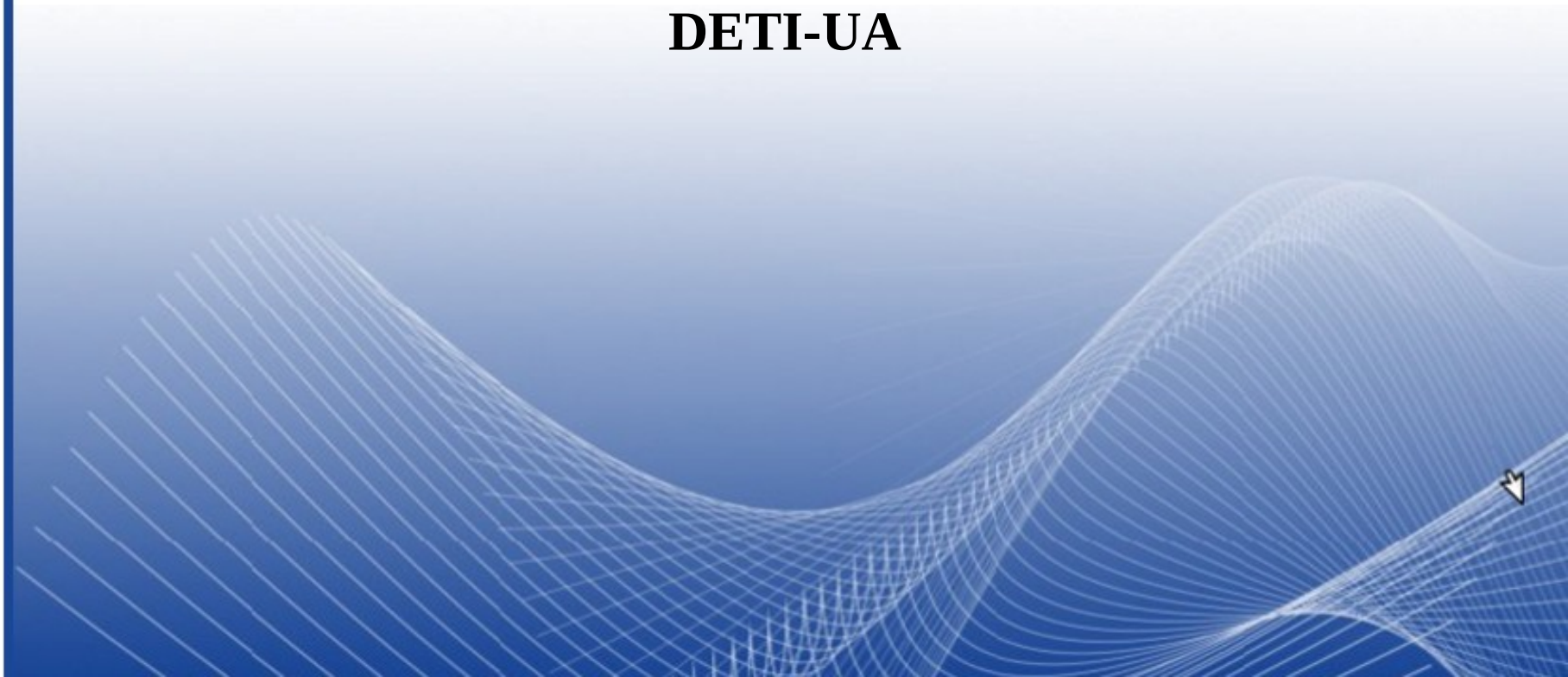
Network Physical Layer

Redes de Comunicações I

Licenciatura em Engenharia de Computadores e Informática
DETI-UA



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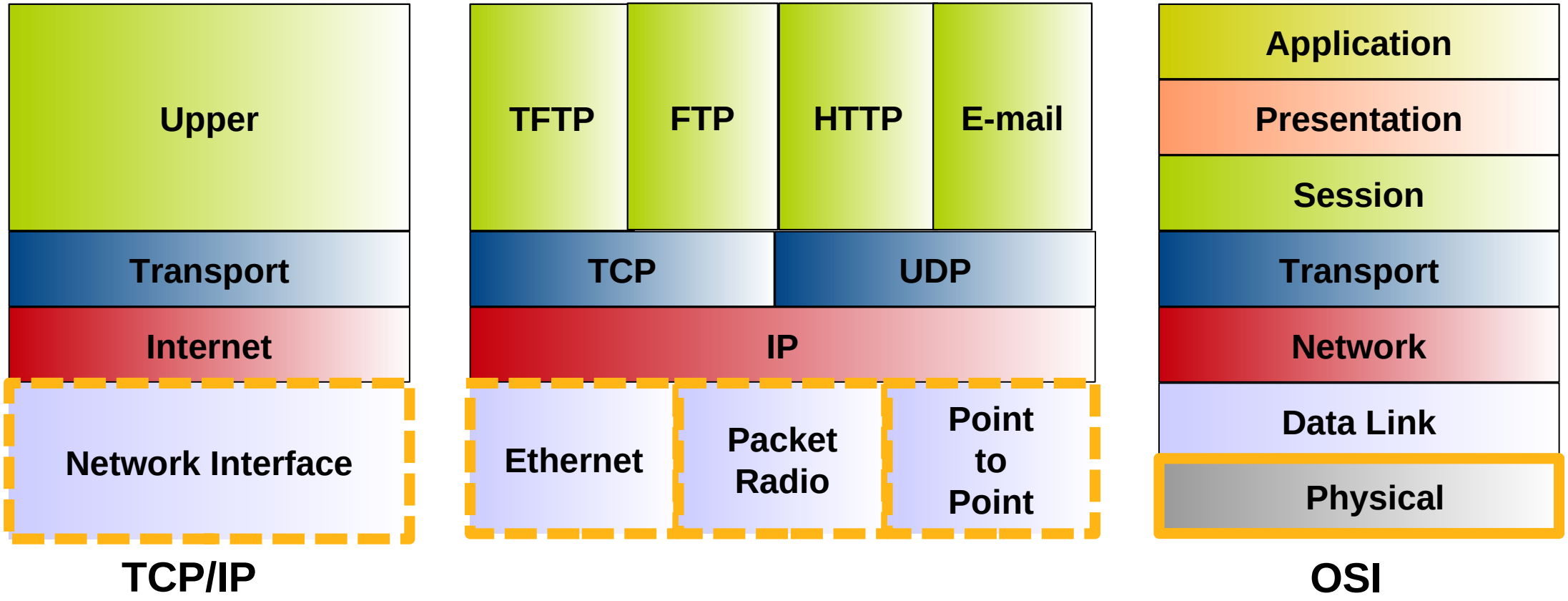
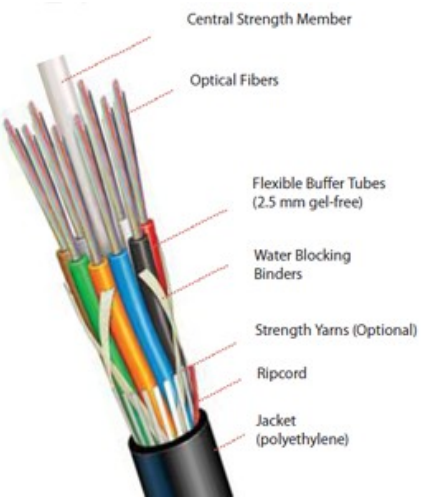
TCP/IP Reference Model

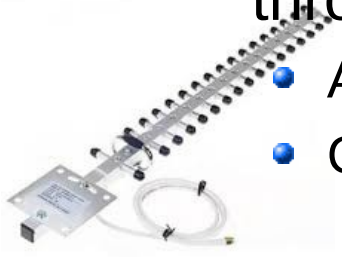


Guided/Unguided Transmission Systems



Microwave link

Free Space Optics (FSO)



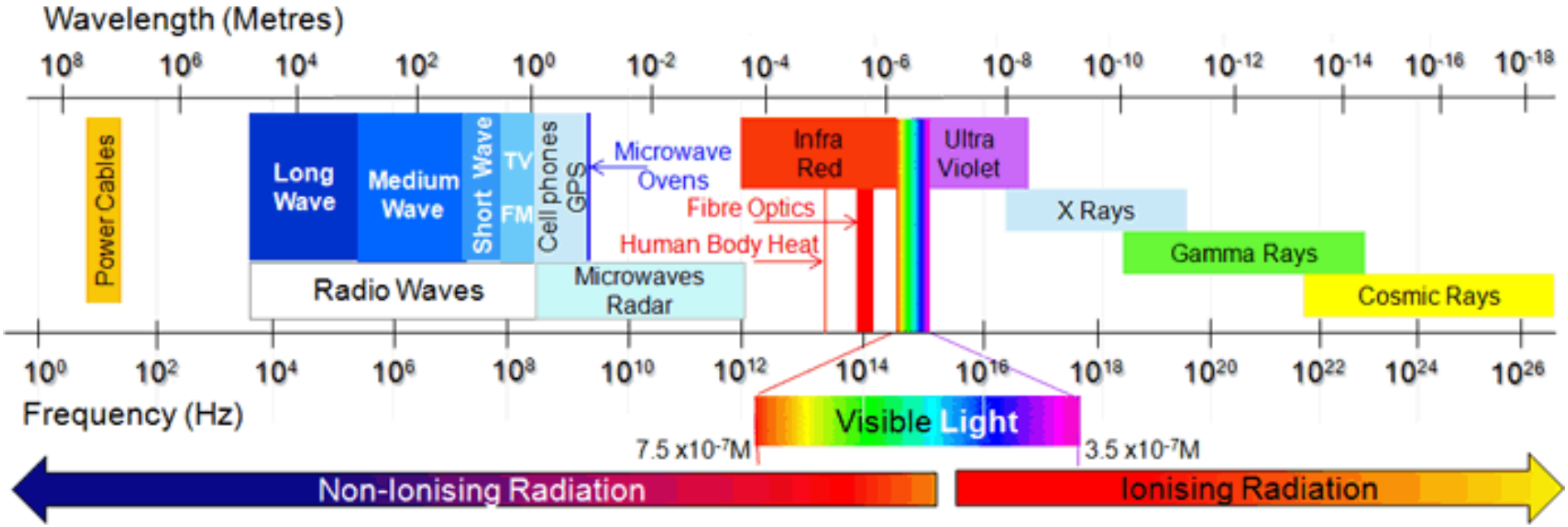
Directional LTE

Omnidirectional LTE

802.11 Omnidirectional

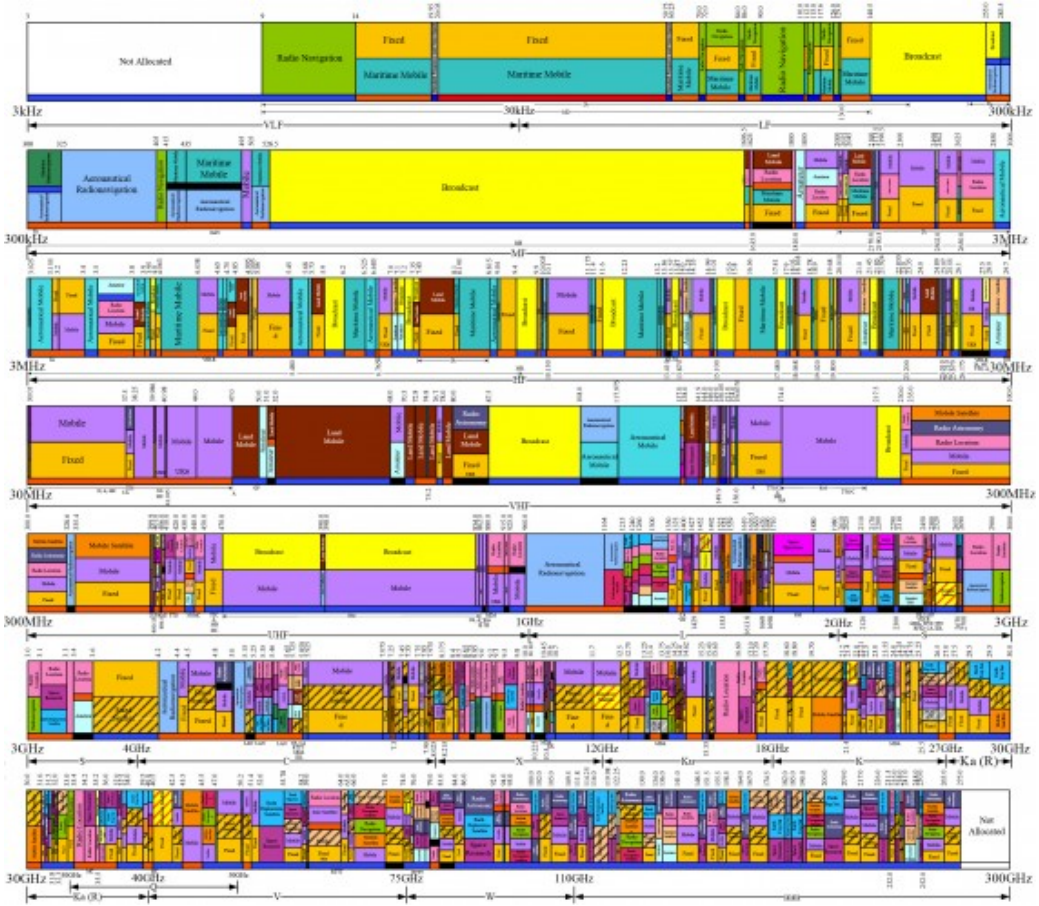
- A transmission system can be classified as **Guided** or **Unguided**.
- In **Guided** systems, a signal travels through a bounding physical medium.
  - Copper cable, Optical fibre, …
- In **Unguided** media, a signal travels through a boundless medium
  - Air, Water, Vacuum, …
  - Can be directional or omni-directional.
    - In directional configuration, the source emits a focused beam in a particular direction.
      - The receiver should be aligned for receiving the signals.
    - In omni-directional configuration, the source emits equally in all directions.

Electromagnetic Spectrum



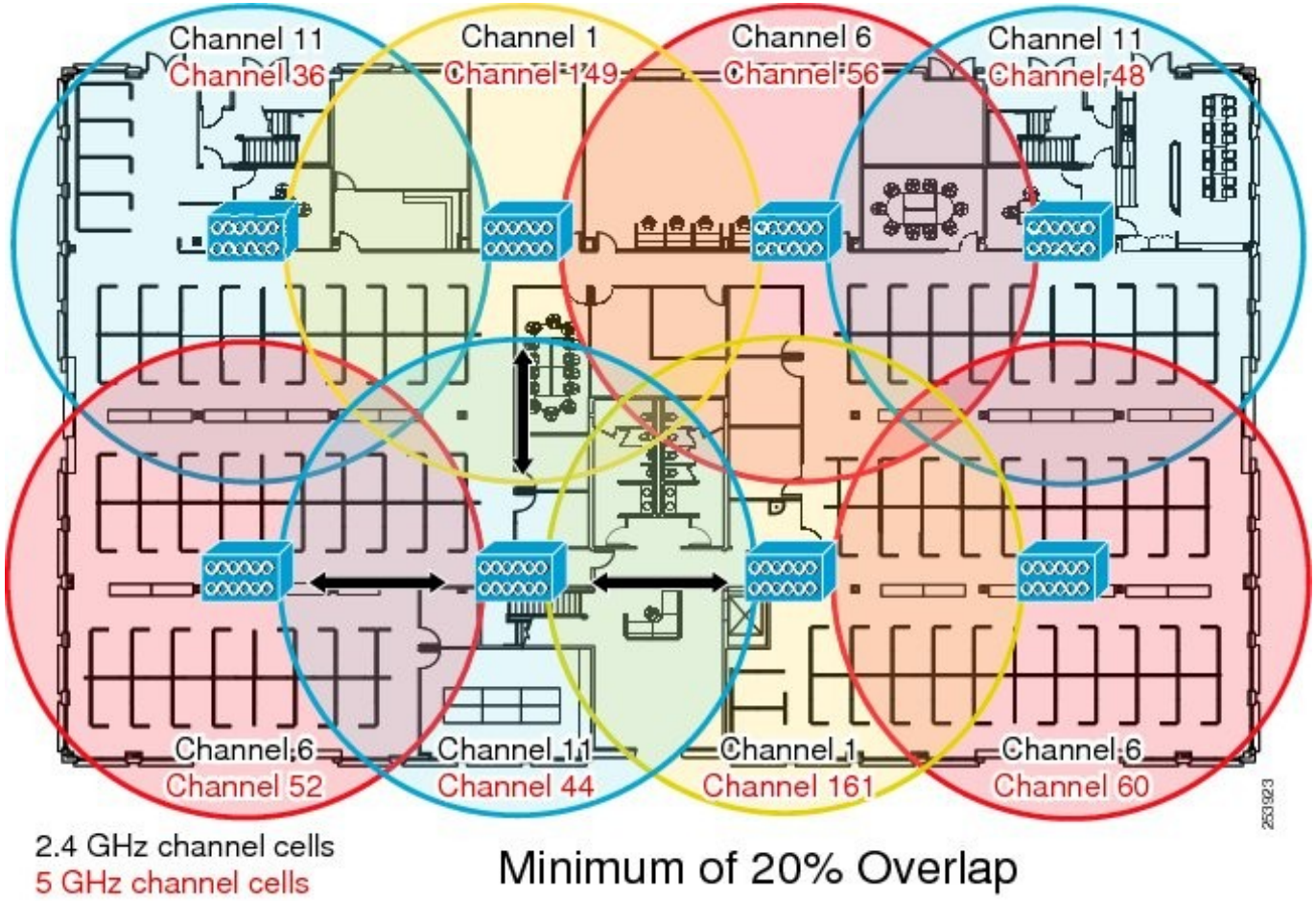
- For radio signals the antenna transmits a sinusoidal signal (“carrier”) that radiates in air/space.

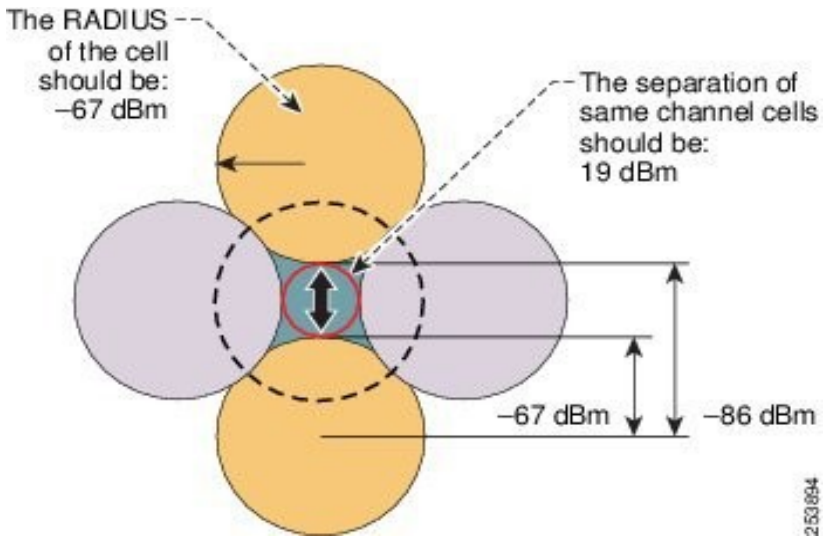
Radio/Microwave Spectrum (3KHz-300GHZ)



- Portugal (ANACOM)
  - https://www.anacom.pt/render.jsp?categoryId=150422
- UK (OFCOM)
  - https://www.ofcom.org.uk/spectrum/information/uk-fat
- USA (FCC)
  - https://www.fcc.gov/engineering-technology/policy-and-rules-division/general/radio-spectrum-allocation
- ...

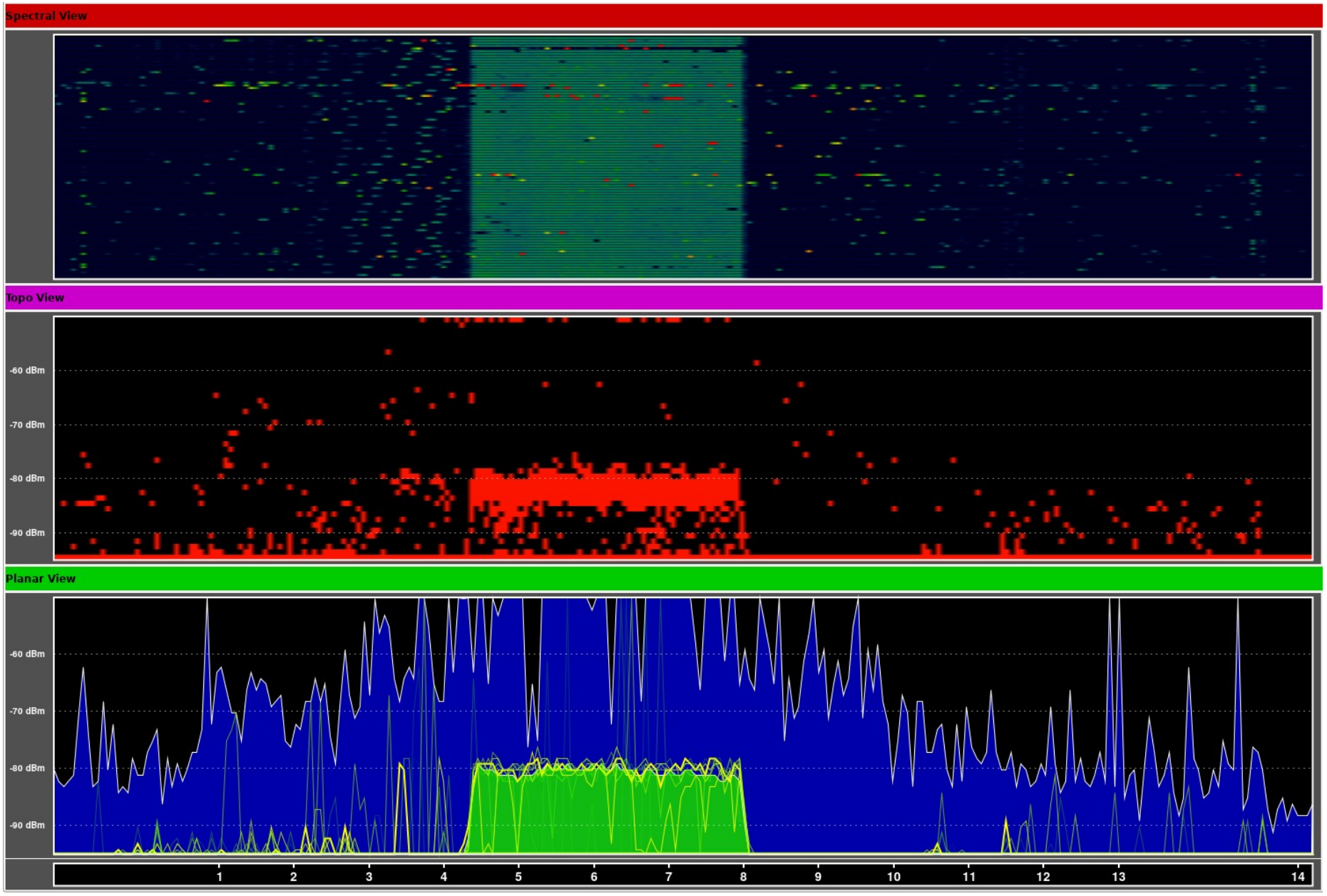
AP Placement and Channel Allocation





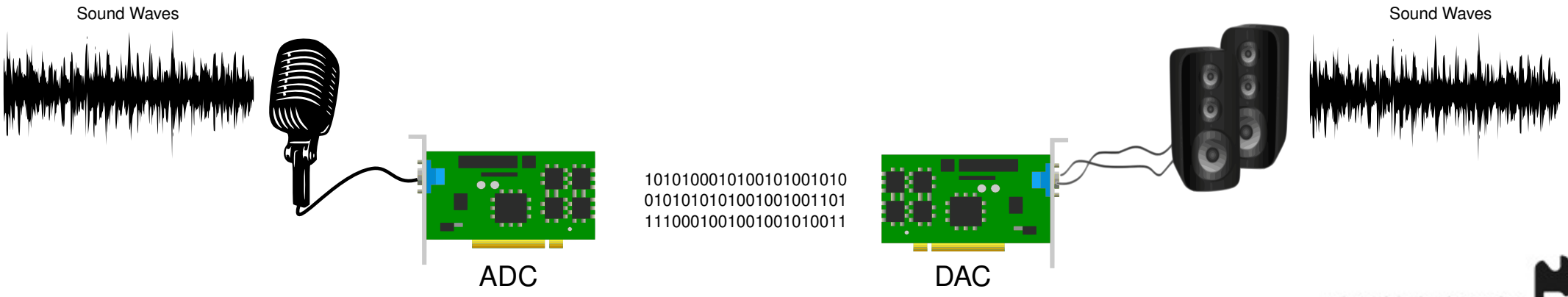
- 802.11n or 802.11ac 5GHz deployment does not have the overlap or collision domain issues of 2.4GHz.

Usage of Spectrum Analysis

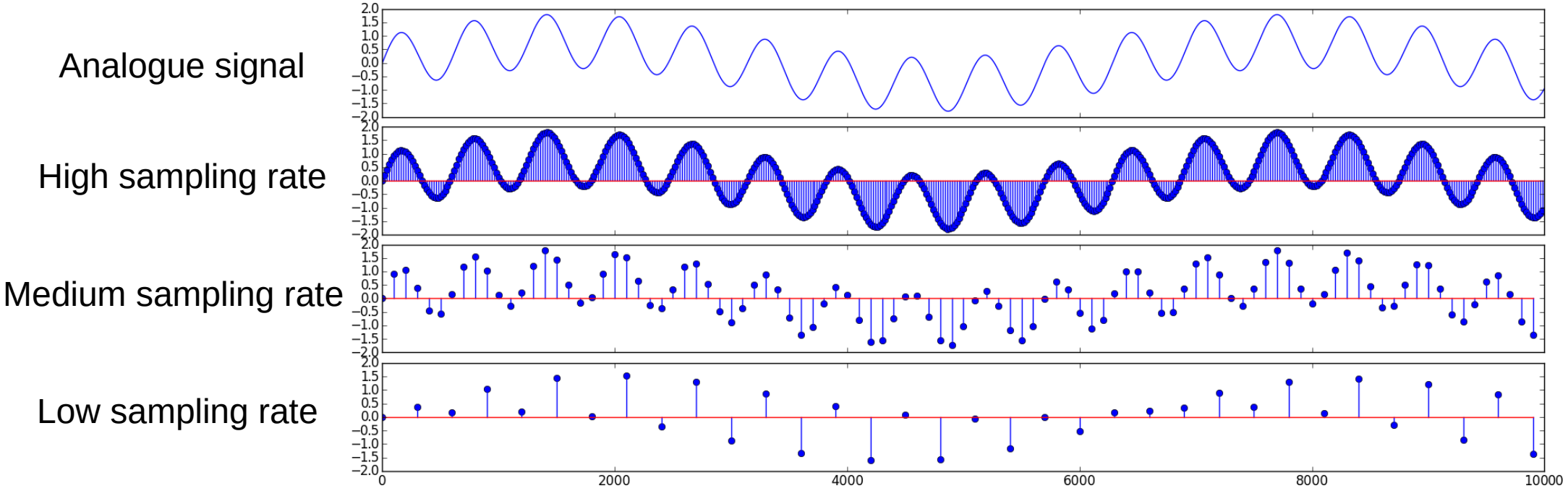


Analogue-Digital Conversion

- The digital transmission of analogue signals requires:
  - An ADC in the source, and
  - A DAC in the destination.
- ADC (Analogue to Digital Conversion)
  - Sampling
  - Quantization and Encoding
- DAC (Digital to Analogue Conversion)
  - Signal reconstruction



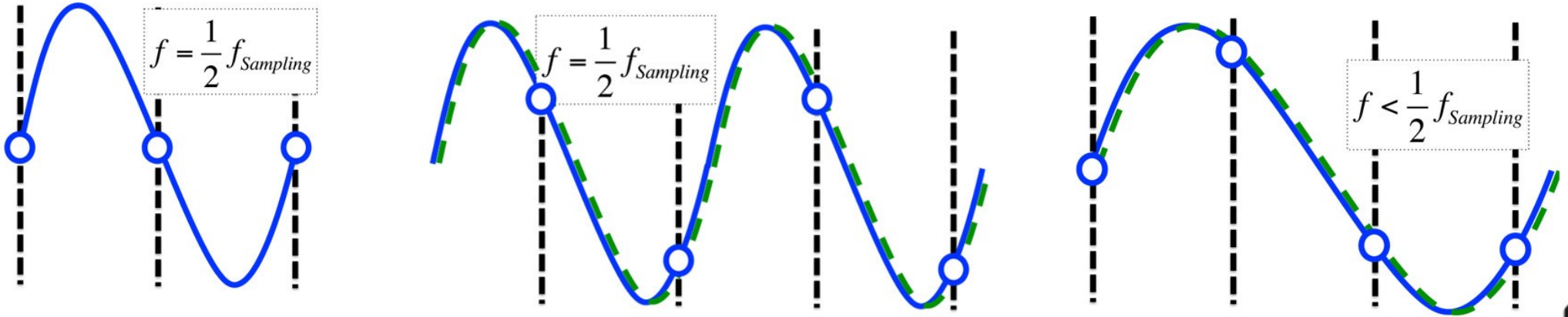
Sampling



- The sampling process, measures and quantifies the analogue signal at equally space time intervals.
- The sampling process must be able to capture the main characteristics of the original analogue signal.
- The sampling rate determines the amount of information that its transferred to the digital signal.

Sampling Theorem

- To reconstruct a signal from the samples, the sampling frequency must be high enough to capture the relevant signal information (frequency components).
  - Sampling frequency is the number of samples per second (f_s).
- For a signal where the highest (relevant) frequency is f_m, the sampling frequency (f_s) must be higher than two times f_m
  - $f_s > 2 * f_m <=> f_m < f_s / 2$
  - $f_s / 2$ is called the **Nyquist frequency**.
  - $2 * f_m$ is called the **Nyquist rate**.



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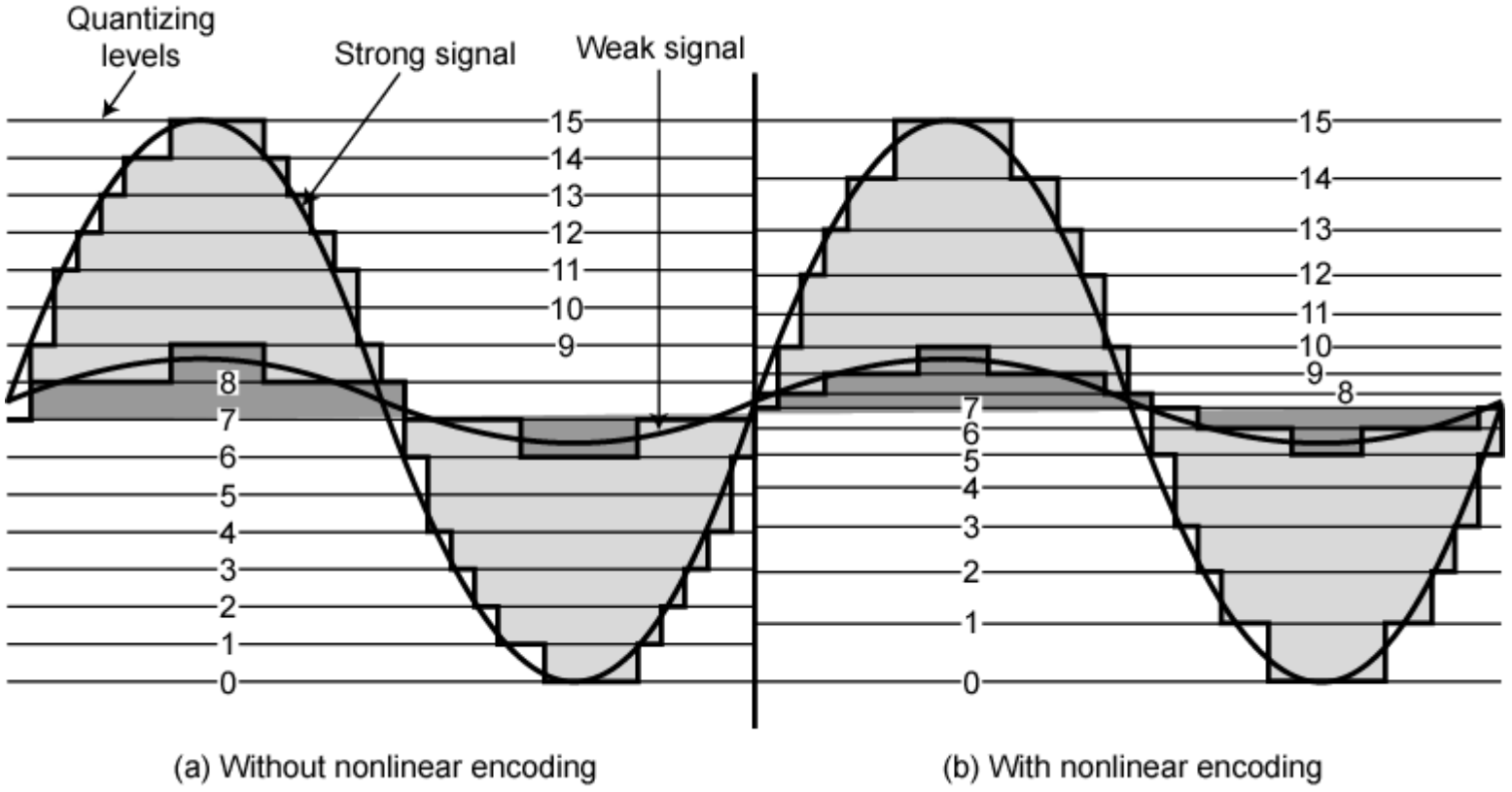
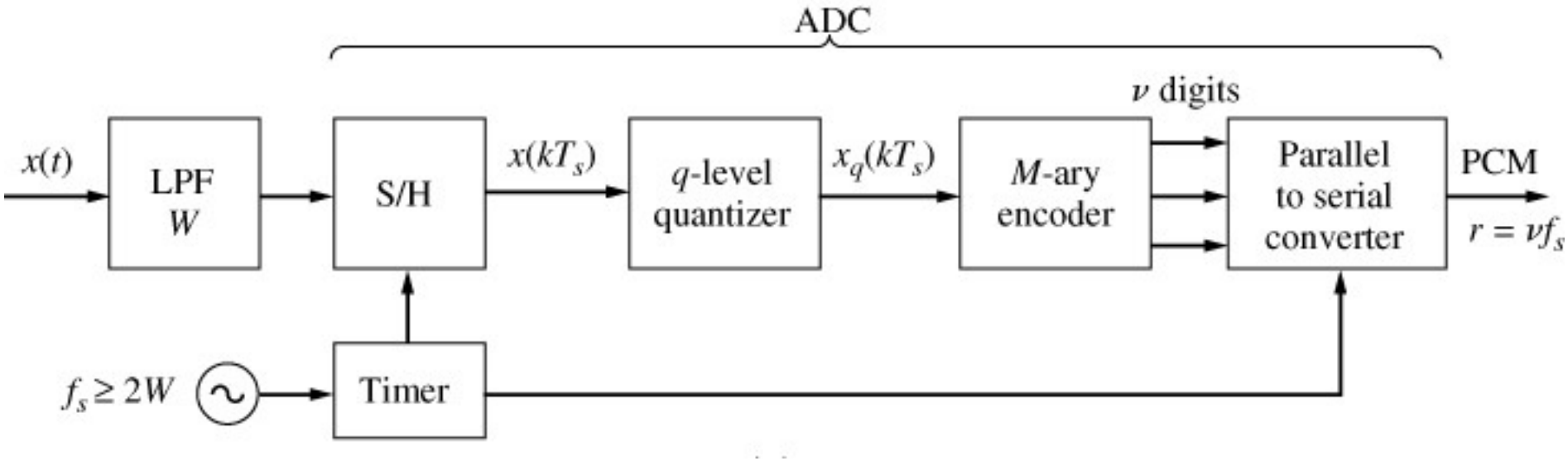
Signal Quantization and Encoding

- Each sampled value must be “rounded” to the nearest member of a set of discrete values.
- The resulting value is then encoded into a binary format.



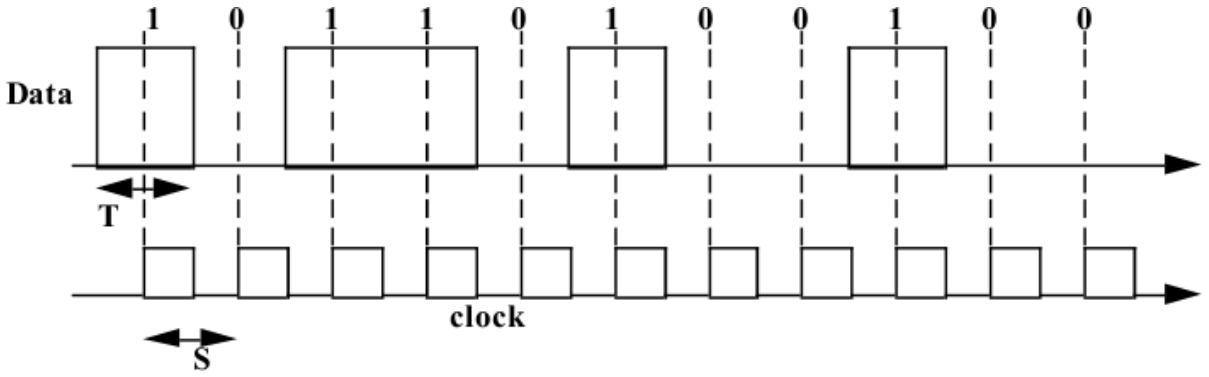
Pulse Code Modulation (PCM)

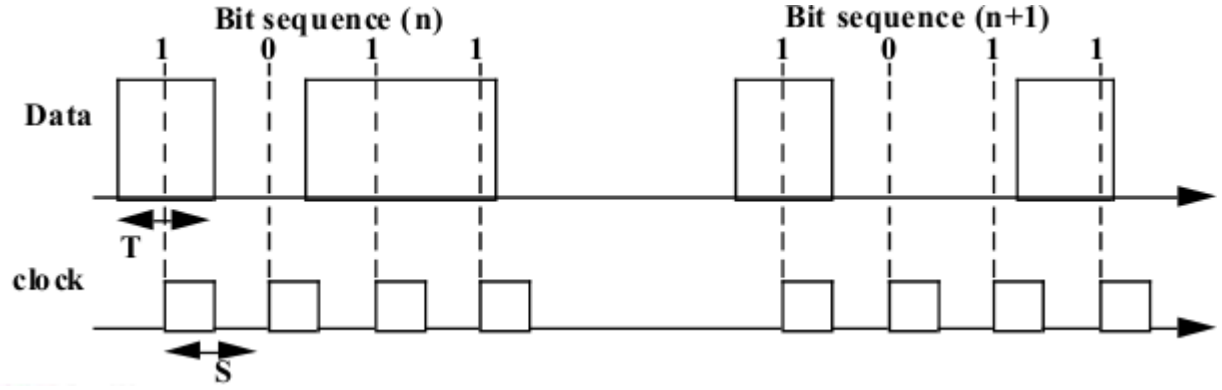
- All mechanisms of an ADC can be implemented using a PCM encoder.



Digital Transmission

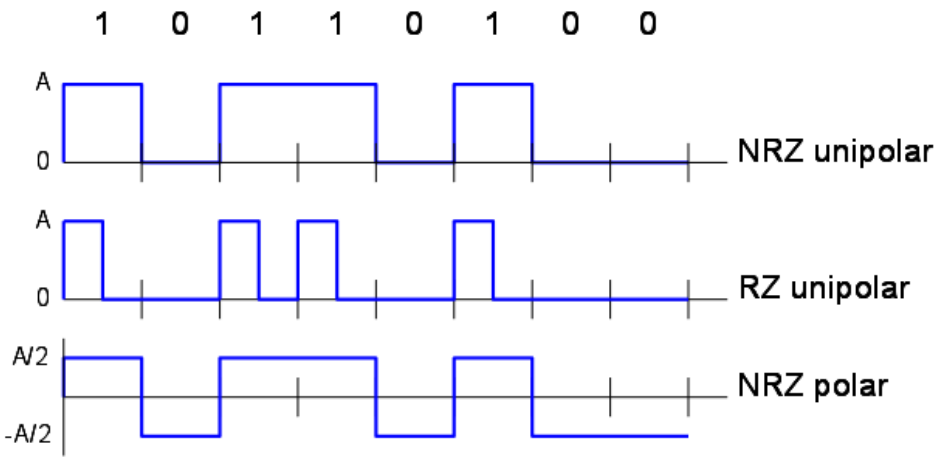
- Can be synchronous or asynchronous.
  - Synchronous Transmission data is transferred in the form of frames.
  - Asynchronous Transmission data is transmitted 1 bit or byte at a time.
- Synchronous Transmission requires a clock signal between the sender and receiver.
- Asynchronous Transmission sender and receiver does not require a clock signal, but data blocks must have a parity bit attached to it which indicates the start (start bit) of the new byte.
  - And, an optional stop bit.

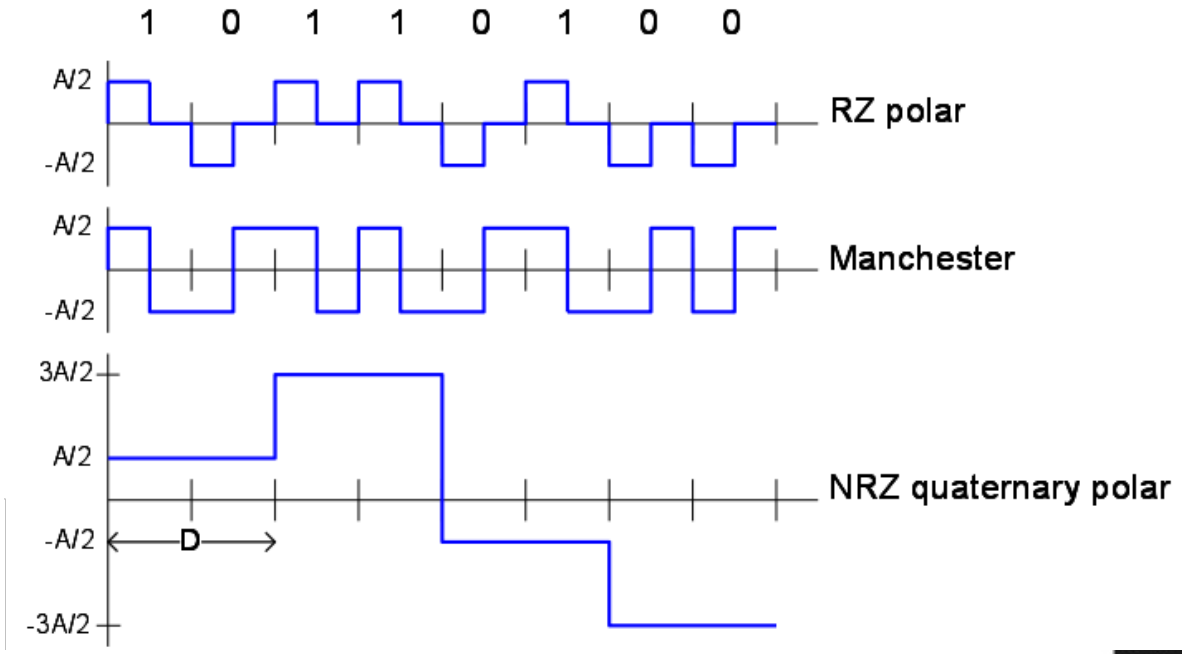




Line Coding (1)

- Line Coding converts a binary sequence into a digital signal
- Sender then uses the digital signal to modulate transmitting signal in a way that the receiver can recognize.
- Line Coding can be done bit a bit, or in block of several bits (symbol).
- There are several (bit a bit) Line Codes:





Line Coding (2)

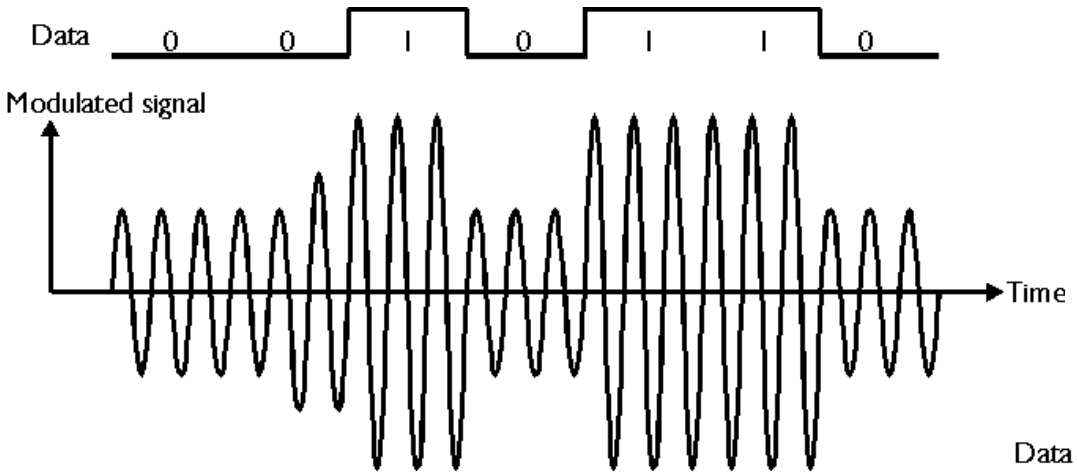
- mB/nB Encoding
  - Symbols of m bits are coded as line symbols of n bits.
  - Each valid line symbols has at least two 1s.

4B/5B Code

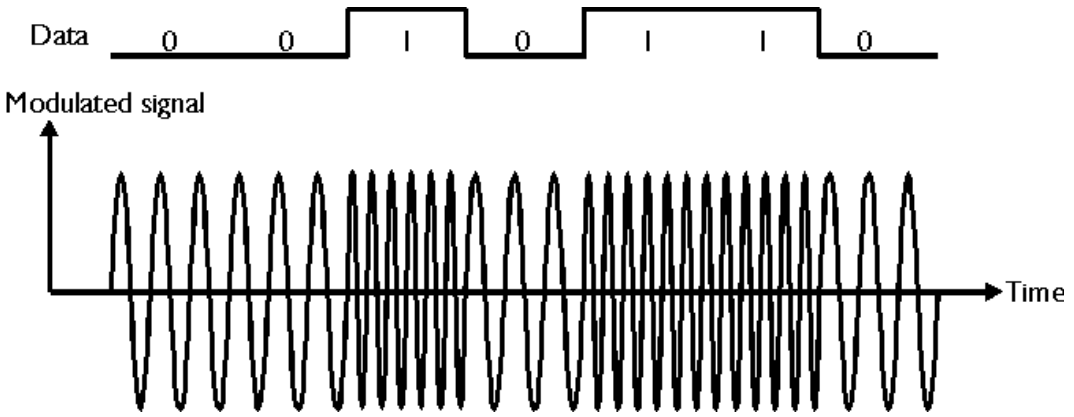
Bits	Symbol	Bits	Symbol
0000	11110	IDLE	11111
0001	01001	J	11000
0010	10100	K	10001
0011	10101	T	01101
0100	01010	R	00111
0101	01011	S	11001
0110	01110	QUIET	00000
0111	01111	HALT	00100
1000	10010		
1001	10011		
1010	10110		
1011	10111		
1100	11010		
1101	11011		
1110	11100		
1111	11101		

Modulation (1)

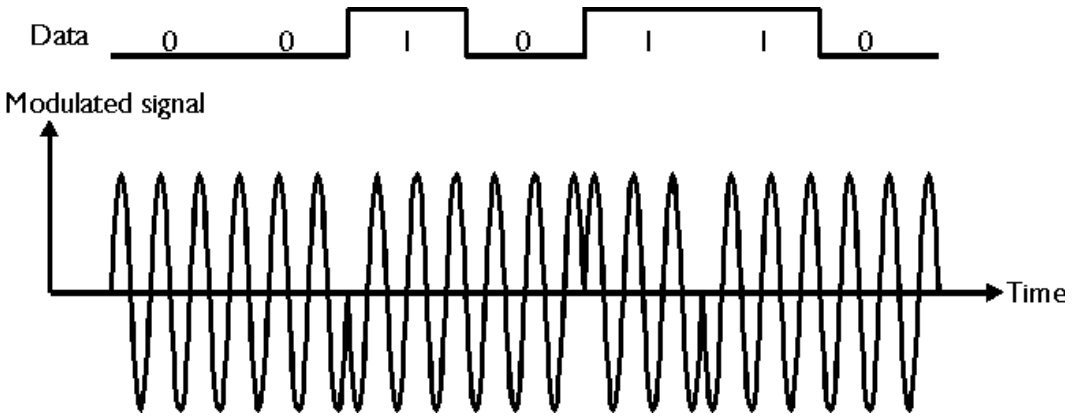
- Amplitude



- Frequency

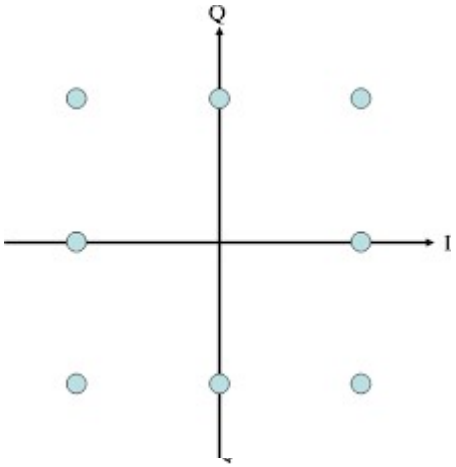


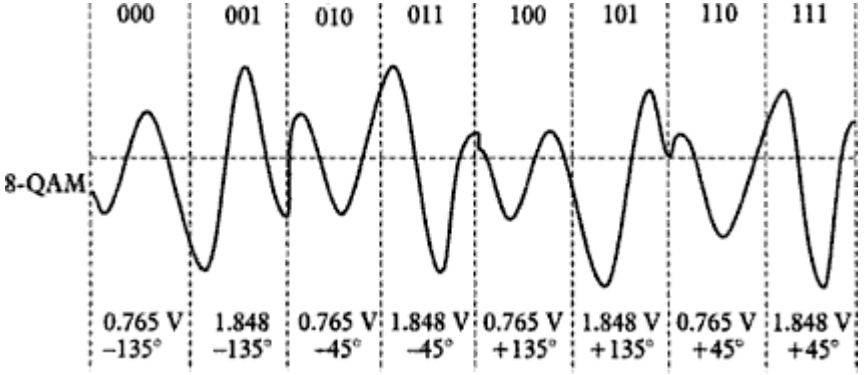
- Phase



Modulation (2)

- Quadrature Amplitude Modulation (QAM)
  - Uses 2-Dimensional signalling
    - Quadrature ← Sine wave + Cosine wave
  - $s(t) = I(t)cos(2\pi f_0 t) - Q(t)sin(2\pi f_0 t)$
- 8-QAM





- 16-QAM